

on the Foundation Day of the cultural complex – Silpgram that was set up in 2006. The place is also famous for organization of cultural performances, folk dances and music events.

9.6.4.5 *Handlooms and Handicrafts*

Guwahati enjoys a pride of place in the country for its rich heritage of artistic craftsmanship. The crafts of this region are almost entirely oriented to locally available materials and moulded by skilled craftsmen. The skill, which is pioneered by their ancestors, is presently providing



employment to the local villagers. Multi-coloured masks, firewood crafts, can & bamboo and fiber works bear eloquent testimony to the fine artistic temperament and imagination of the traditional craftsmen of Assam.

Products like Silk, Muga and Eri fabric, Dry flower, Orchids and cut flower, Jute yarn, jute fabrics, Wood carving products, Cane and bamboo furniture /other cane products, Terracotta, Gunny Bags, Jute twine, Jute tea bags, Jute handicraft, Jute, Cotton blended handloom fabric, Belt metal wares, brass metal are produced locally around Guwahati

The names of places where the above-mentioned items are produced, are given below:

Sr. No	Handicrafts Item	Name of the place	District/city
1	Silk, Muga and Evdi fabric	<ul style="list-style-type: none"> • Ambari • Bamuni Maidan • RGB Road • Chandmari 	Guwahati Guwahati Guwahati Guwahati
2	Dry Flower	Dispur	Guwahati
3	Orchids and cut flower	Noonmati	Guwahati
4	Jute yarn	Ambari	Guwahati
5	Wood carving products	Kachubil	Darrang
6	Cane and bamboo furniture	<ul style="list-style-type: none"> • Bamuni Maidan • Jakhalabanda 	Guwahati Nagaon

		<ul style="list-style-type: none"> • Kaithal Kuchi • Chitra Patty • Gopinath Nagar • North Bongaon • Sibsagare • Cachar 	Nalbari Tinsukia Guwahati Kamrup Nalbari
7	Bell metal wares	<ul style="list-style-type: none"> • Sarthebari • Titabor • Roha 	
8	Brass metal	Hajo	Kamrup

Assam has the longest concentration of weavers in India. Handloom weaving and its vast range of design reflect the sartorial taste of multi faceted composite culture and tradition of Assam. There is hardly any village in Assam where one will not hear the rhythmic sound of the looms and shuttle. Designed dress materials produced by weavers of Sualkuchi, are highly claimed for its uniqueness and quality standards.

The women make mekheles, chadars, rihās, gamochas etc. The famous viudavani vastra now preserved, in London museum in a bit and pieces, was woven by Sri Sankaradeva, the great religious and social leader of the 16th Century. The most common patterns woven on the clothes are the fairy tales with artistic sensibility.

9.6.5 Leisure Tourism

9.6.5.1 Assam State Museum

Assam museum is situated in core city area Guwahati near Uzanbazar. It has collection of sculptures, costumes and ethnology, paintings, ivory and metal work.



9.6.5.2 *Srimanta Sankardeva Kalakshetra:*

Located at Panjabari in Southern part of Guwahati, Kalakshetra was conceived after the 1985 as a grand exposition of the life and culture of the people of Assam. Srimanta Sankardeva kalakshetra is a multi-arts complex named after a great Vaishava Saint and the greatest integrator of Assamese Society. It is a house for the preservation and exhibition of the cultural objects and day-to-day articles and by different ethnic groups. It has got an open-air theatre with 2000 capacity for holding folk festivals, dance, dramas etc. offering an atmosphere of village of Assam. It has also got a library of rare books collection.

9.6.5.3 *Bhupen Hazarika Smarak*

The most solemn of the cultural spaces is perhaps Bhupen Hazarika Memorial, set up where the music maestro's body was cremated on 5th Nov 2011 at Jalukbari. The five bigha of land of this memorial was provided by Gauhati University. The blueprint for the complex includes a two-storied structure containing a library with rare photographs of Hazarika and an audio-visual room, an open-air theatre, a musical fountain and a souvenir shop.

**9.6.5.4 *Planetarium***

The only one of its kind in the Northeast, this planetarium in Uzanbazar adjoining a Ganesh temple is a prime attraction as well as a centre for astronomical research.



9.6.5.5 *Nehru Park*



Nehru Park is one of the oldest parks in Assam. It is a public park in the heart of Guwahati city opposite the premier education institute, Cotton College. It is a major tourist attraction of the city as well as a place of recreation and walks for the Guwahati citizens. Historically, the area of the park earlier was part of an old church that was later developed by the Assam

Government. Nehru Park in Guwahati has 45 concrete statutes that depict the various dance forms of the state of Assam.

9.6.5.6 *Shraddhanjali Kanan Park*

In 2011, GMDA built the city's largest park – Shraddhanjali Kanan opposite the Assam State Zoo – on 23 bighas of land acquired from the Soil Conservation Department. The park is a popular address for the city's joggers and morning walkers, as is Srimanta Sankaradeva Kalakshetra. The Rs



8.73crore Shraddhanjali Kanan is a recreation cum educational centre modelled on the lines of London's Hyde Park. The park offers a music fountain and a laser show depicting Assam's history. It also hosts an annual urban winter festival of music, food and art.

9.6.5.7 *Regional Science Centre*



Regional Science Centre, Guwahati (situated at Jawharnagar, Khanapara) is an activity driven non formal science education destination for all spectrums of population. Here science comes alive with a vibrant science park with an adjacent Prehistoric park, 3D science movies, science

shows. The indoor and outdoor expositions like the mirror magic, Fun science, Children's corner, Butterfly corner, large aquarium, and many more offer you an experience-based science education in a never before way

9.6.5.8 Accoland Theme Park

The first and the biggest amusement park in the northeast is located near Rani area on the out skirt of Guwahati. It has some amazing and thrilling rides as well as a wave generating pool. The park is well equipped with different 29 theme rides ranging from child to adult.

9.6.5.9 Bhagwan Mahavir Udyan

Local administration turned the Brahmaputra riverfront along MG Road into adjacent parks as Bhagawan Mahavir Park turned into an embarkation. This park is located on Southern bank of Brahmaputra opp to pan bazar area.

**9.6.5.10 Indira Gandhi Stadium**

Indira Gandhi Athletic Stadium, also known as Sarusajai Stadium, is a football stadium in Guwahati, Assam, India. It is the current home ground of NorthEast United FC. Besides hosting football matches, the stadium is also used for athletics. It had a total capacity of 35,000 which was later reduced to 25,000 due to installation of bucket seats for 2017 FIFA U-17 World Cup, which was hosted in India.

In 2007, it hosted the 33rd National Games of India and in 2016, hosted the 12th South Asian Games. The stadium hosted the Assam Global Investors' Summit on 3 and 4 February 2018 and the 65th Filmfare Awards on 15 February 2020.



9.6.5.11 *Barsapara Cricket Stadium*

The modern Dr. Bhupen Hazarika or Barsapara Cricket Stadium, started in 2007, was completed in 2013. It has a seating capacity of 60,000 people. The Cricket Stadium is India's 49th international cricket



venue. First International cricket match played here was between India and Australia T20I. It is a new stadium which hosts domestic and international cricket matches.

9.6.5.12 *Dr. Zakir Hussain Aquatic Complex*



Guwahati's sporting infrastructure changed dramatically after Assam won the bid to host the 33rd National Games in 2007. The facilities that came up were considered world class. They include the Dr Zakir Hussain Aquatic Complex and the Karmabir Nabin Chandra

Bordoloi AC Indoor Hall at Sarusajai.

9.6.5.13 *Maniram Dewan Trade Centre*

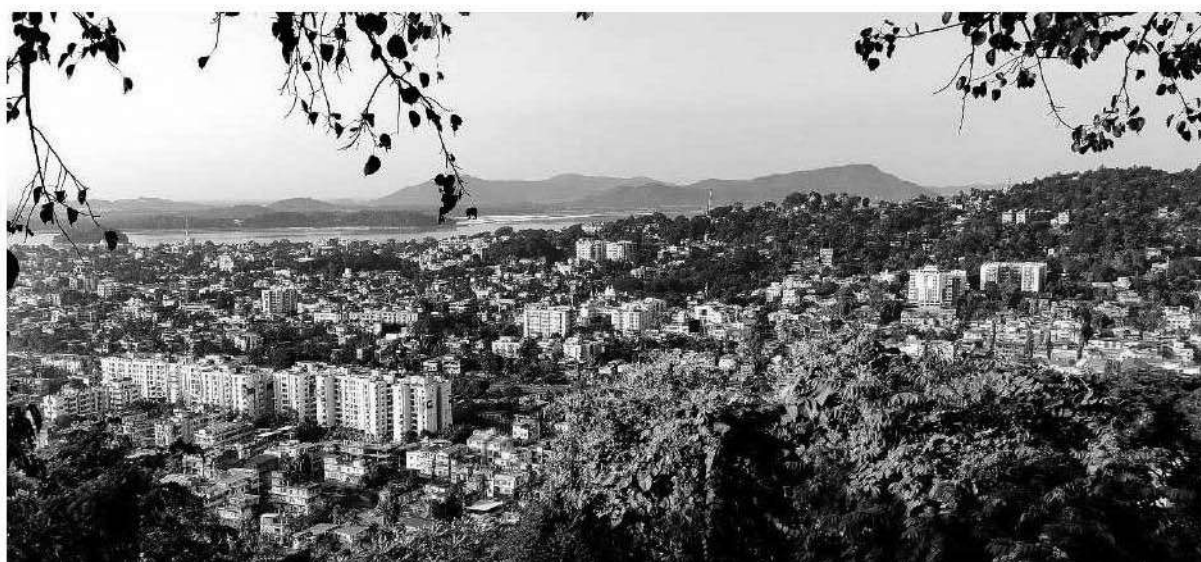
The grandest address for trade and industry expositions in the Northeast is Maniram Dewan Trade Centre, named after the first native tea planter and also the first Indian CEO of MNC the London-registered The Assam Company Ltd.



The trade centre is an integrated system of buildings and open spaces stretched over an area of 10 acres in the city's Betkuchi area. Inaugurated in February 2009 and managed by Assam Trade Promotion Organisation, the centre has hosted several international trade fairs and business meets besides showcasing the rich art and culture of the Northeast.

9.6.5.14 River Cruise

MG Road, the city's answer to Mumbai's Marine Drive, is lined with jetties to board floating restaurant, discotheque too – that package a variety of cuisines with cultural shows. This is also the stretch to board luxury cruises for an unforgettable trip to silk town Sualkuchi in the west and Kaziranga National Park in the east.

**9.6.5.15 Hilltop viewpoints**

A number of hills criss-crossing Guwahati ensure a panoramic view of the city and beyond. One can drive up these hills or be adventurous enough to scale. These hilltop viewpoints are Nilachal (Kamakhya Temple), Chitrachal (Navagraha Temple), Sarania (Gandhi Mandap, museum dedicated to Mahatma Gandhi), Hengerabari Nongkeh (Assam State Zoo), Sandhyachal (Basistha Ashram), Narakasur (Guwahati Medical College), Kalapahar (from a Shiva Temple accessible from Kalapahar and Birubari localities), Fatasil and Adamgiri (behind NF Railway headquarters). Geeta Mandir, on a hillock at Geetanagar, offer's a bird's eye view of Guwahati refinery and adjoining areas.

9.6.5.16 Sarighat Setu



The Saraighat Bridge is a rail-cum-road bridge over Brahmaputra River in Guwahati, Assam and is the first of its kind bridge over the river in the state. The length of the bridge is 1492 meters (4895 feet) and the road on the bridge is 7.3 meters (24 feet) wide. The bridge was built between 1959 and 1962 by Hindustan Construction Company at a cost of Rs 10.6 crore at that time. The bridge was completed in September 1962 and the first engine rolled across it on 23 September 1962. The bridge is known to connect Northeast India with the rest of the country. The bridge is 40 feet above the normal flood level of the river which also ensure free navigation.

9.7 Issues and Potential

The Guwahati city has immense potential and scope for the tourism industry. Guwahati is best known for her unique natural beauty with flora and fauna, historical monuments, river front, Island, Spiritual Places, Reserved Forest and its colourful cultural festivals. The various places of visit can be nature related, religious, historical etc. Development of Tourism circuit connecting all ancient spiritual places with NMT and Public transport system. The whole tourism potentialities can be grouped together under the following categories:

1. Ethnic Tourism
2. Wildlife Tourism
3. Leisure Tourism
4. Heritage Tourism
5. Eco Tourism
6. Spiritual Tourism

→ **Main Focus**

9.7.1 Heritage Issues

1. ***Dilapidated Condition of structures***: Major of the heritage structures are in dilapidated condition due to the unavailability of conservation, restoration and preservation practices in Guwahati area. These structures need periodic preservatory treatments in order to enhance their cultural life for coming generations.
2. ***Unavailability of Infrastructure and Services***: There is an absolute absence of proper infrastructure and services in the immediate areas around the possible heritage as well as tourist spots of Guwahati. The basic tourist amenities also lack at these places which have to be planned accordingly.
3. ***Absence of Monitoring***: There is no nodal body responsible for periodic monitoring of the heritage structure around Guwahati. Such nodal bodies are to constituted in order to provide proper jurisdiction to such capable heritage areas so that there's no threat to them in future.
4. ***Haphazard Development***: The unplanned developmental activities around the heritage sites are serious threats and it harms the integrity of the heritage structures. Such activities are to be monitored by a proper administrative framework under by the local, regional or state authorities.
5. ***Lack of Awareness among Public***: The citizens are unaware about the cultural assets owned by them and they are to be made aware in order to have proper public participation in order to preserve such important historic sites. Public participation is an utmost important aspect for the conservation of any site.
6. ***Absence of Legal Plan***: There is an absence of a visionary master plan available specifically for the heritage sites in Guwahati. Such important sites require a separate space in the administrative framework of the authorities in the form of a legal document which has been prepared after consulting proper stakeholders and experts.
7. ***Documentation of Heritage Structure***: The heritage structures of Guwahati region are not documented till date. There is a need of proper listing and documentation of heritage sites in Guwahati. Such sites are to be properly listed under various grades of their importance and documented specifically so that a proper conservation approach can be implemented for such important sites.

9.7.2 Tourism Issues

1. **Poor Road Connection:** The roads are in poor shape in many of the tourist spots. Some of the roads cannot be used during the rainy season. The pucca roads too are crying for attention.
2. **Absence of Tourist Facilities:** A tourist expects some basic facilities like well-maintained toilets and eateries.
3. **Poor Maintenance:** The tourist spots are neglected to say the least. Most of the infrastructure are in bad shape and needs urgent renovation. Caretakers are non-existent which affects the maintenance.
4. **Haphazard Development:** Unplanned and un-organized development activities can be seen round various tourist places and at some of the places, the slum development can be seen.
5. **Lack of Promotional Activities:** There is lack of promotional activities in Guwahati to conserve and protect the heritage structure and values. Residents of the city are not even aware of the importance of culture and heritage of the Guwahati city.
6. **Lack of Awareness among Public:** The peoples visiting the monument or staying in the surrounding area are not concern to save the heritage of the city. Lettering within the premises of the building is the common practice of the people.
7. **Lack of information:** There is lack of information for the tourists regarding the tourist spots, their significance, and location. Guide facilities are also not there.

9.8 Policies for Tourism Development

As a service industry, tourism has numerous tangible and intangible elements. Major tangible elements include transportation, accommodation, and other components of a hospitality industry. Major intangible elements relate to the purpose or motivation for becoming a tourist, such as rest, relaxation, the opportunity to meet new people and experience other cultures, or simply to do something different or have an adventure.

Tourism is vital for every place, due to the income generated by the consumption of goods and services by tourists, the taxes levied on businesses in the tourism industry, and the opportunity for employment and economic advancement by working in the industry. For these reasons government and private agencies sometimes promote a specific region as a tourist destination and support the development of a tourism industry in that area. The contemporary phenomenon of mass tourism may sometimes result in overdevelopment; however alternative forms of tourism such as ecotourism seek to avoid such outcomes by pursuing tourism in a sustainable way.

Guwahati Region offer great potential for tourism development. According to the existing scenario analysis, it has been observed that the following categories of tourism have immense potentialities for this region:

- Nature based outdoor recreation and Eco-tourism for wetlands, pukhuries, Brahmaputra riverfront, tea estates, botanical garden, hills and undulating landforms including picnic spots, sightseeing, camping sites etc. Presence of all these tourism products calls for the growth of Adventure Tourism.
- Religious Tourism with historically important structures such as temples and other outdoor worshipping areas in the vicinity.
- Heritage Tourism with old architectural building, British dynasty build structures and annual/seasonal traditional village fairs and festivals, folk or tribal socio-cultural events with arts, crafts, music, dance etc.

9.8.1 Common Strategies

- Promote Homestays to help tourists experience Guwahati's culture.
- The Govt. wants to boost tourism in and around Guwahati. As part of this, they intend to promote homestay, heritage and spiritual Tourism circuit within GMPA.
- Targeting the middle and upper middle-class tourists, the homestay units are proposed which will enable them to experience Guwahati hospitality, cuisine, customs and traditions by staying with families.
- This system will benefit the owner of the house and make it easy for tourists who find it difficult to get hotel accommodation in peak season.
- Under the Heritage Circuit the following works can be taken up:
 - Revitalization of streetscapes in the Heritage Area in Guwahati
 - Beautification and improvement of MG Road, GS Road and AT Road in Guwahati being a major heritage center of city.
 - Beautification of Basistha River stretch as public promenade passing through core city area of Guwahati.
 - Toilet facilities to be provided at tourist spots
- Public toilets at every major junction and public gathering spots as well as developing areas are to be provided for public convenience. It is to be provided especially in area where the tourists inflow is higher so that it can be utilized fully.
- Guided boat rides on the river could be provided to the resort guests who show a preference for it. Angling kit could be provided too for those who wish to amuse themselves with on-board fishing.
- By providing suitable incentives, encourage setting up at choice locations a few beer pubs which have aesthetic and upscale ambience. Tourists and commercial travelers who do not take up hotel accommodation during their visit to Guwahati are likely to patronize such bars.
- Establishment of budget accommodation at one or more suitable locations to cater to the short-period lodging facilities required by visiting artists for participation in the cultural / fine arts / religious festivals, pilgrims, sports persons, student groups / others may be examined by the tourism authorities. Alternatively, like the Grey-hound bus stations in the USA, locker-chests and

wash facilities may be provided for those who opt for these amenities only instead of room accommodation.

- Establishment of “My Bike, My City” concept to help visitors explore the entire city and tourist spots independently by promoting e-Bicycle concept locally.
- None of the leading national hospitality chains such as the Taj, Oberoi, Leela group and ITC hotels division have yet to come to Guwahati. Presence of quality national and international hotel chains will not only attract the high spending domestic / foreign tourists but also attract business conferences / seminars / workshops etc. Suitable steps may be taken in this regard by the authorities concerned to promote holding of conferences / seminars etc in the better class Guwahati hotels / resorts.
- Development of Brahmaputra river front, Sea Plan dock, Cruise facility, Rope way, District Sport Complex, Cultural Complex, , Amusement Park, Water Sport Complex and International Hospitality Chains will probably help boost tourism sector of Guwahati hence boost in local urban-rural economy.

9.8.2 Integrated Approach for Development of Tourism

- Regulating and planning for Tourism to preserve ecology, environment and areas of tourism value.
- Reducing pressure on Core Guwahati city by planning, developing self-contained state of art Tourist destinations in the surrounding settlements.
- Eliminating haphazard and unplanned/ sub-standard development around sites of tourism value.
- Promote Guwahati as a Quality Tourist destination rather than as a mass tourist place.
- Leveraging the concept of Eco-Tourism for the development of places of tourist value.
- Leveraging Tourism for promoting and enhancing the state economy and generation of employment.
- Planning tourism supportive infrastructure with care and put in place on priority in order to exploit the full potential of tourism.
- Planning and developing state of art Convention Centres and supportive facilities to make Guwahati Global Convention Hub.

- Making adequate arrangements for parking as part of the planning tourist sites.
- Planning the circulation pattern for tourist in such a way that City tours can be held for tourists visiting the local sites of heritage value.
- Making Provisions for Public Transportation so that City Bus Tours can be taken up to promote tourism within the city and to minimize traffic on the roads.
- Leveraging strength of Boats to start city tours involving various water bodies, lakes and rivers.
- Coordinated Marketing to attract more tourists from other states and foreigners.
- Enhancing Product Quality so as to create a brand image for tourist destinations and enhancing service quality.
- Enabling Private Sector Participation for accelerated growth of the industry and efficiency in facilities and services.

10. ENVIRONMENT

Environment plays an important role in the sustainability of a region. The balance between different environmental aspects and development defines the progress and livability of an area. The most crucial factors which affects the livability of an area are primarily, land and water. With an increase in the demand of the water, the demand for urban land is also increasing. People flock to urban areas to seek employment, entertainment, shopping and generally a higher standard of living. At the same time, environmental infrastructure for works and services are inadequate to serve the resulting increase in population and population densities.

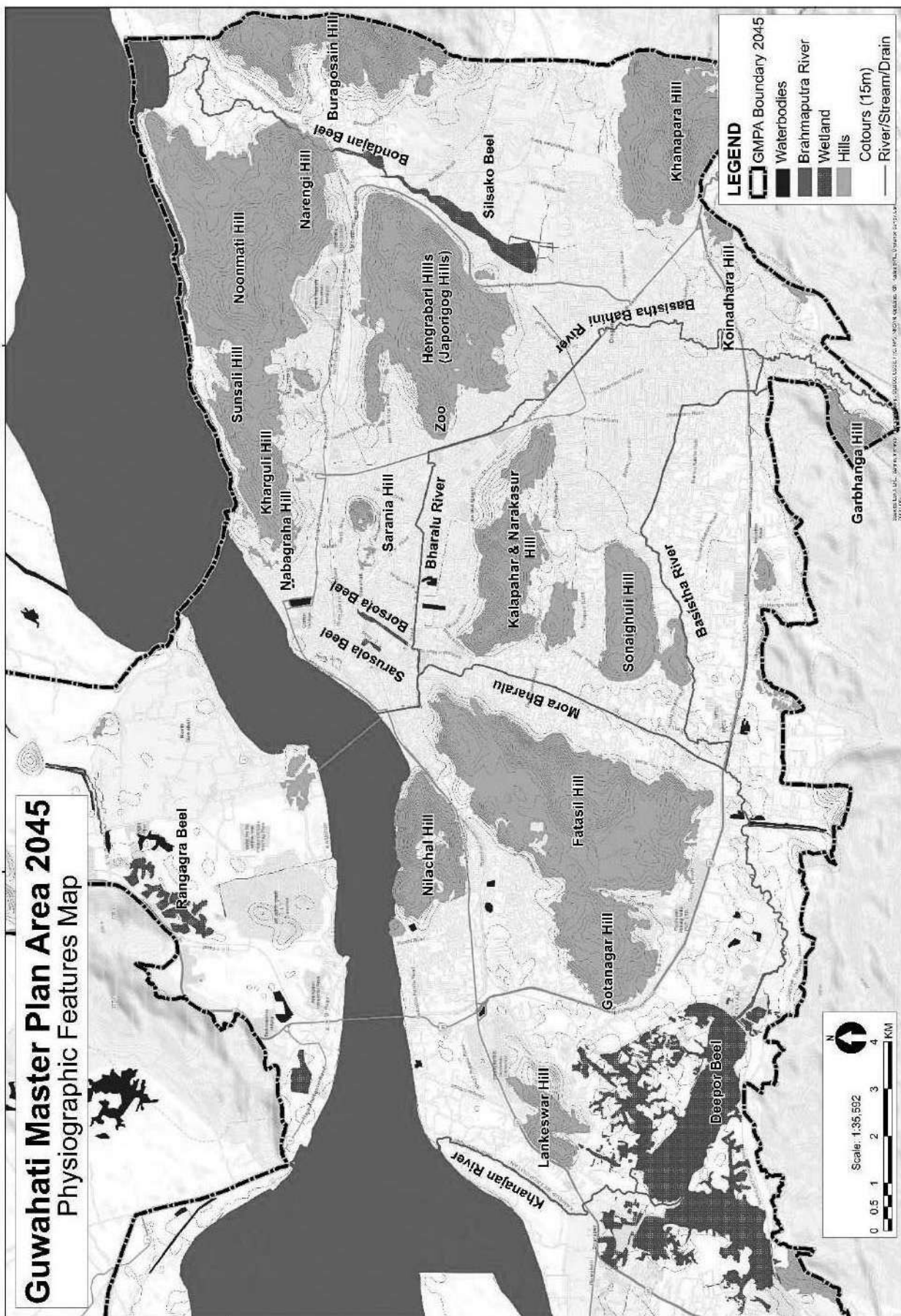
The inevitable congestion causes environmental hazards and degradation until strategies for reversing environmental deterioration can be implemented. Hence, the magnitude of urban population growth in developing countries is a direct indicator of the degree of spatial concentration of people, industries, commerce, vehicles, energy consumption, water use, waste generation and other environmental stresses. Several environmental aspects are considered and studied to access the environmental conditions of the planning area. This analysis is presented in this chapter along with proposed strategies to safeguard the environment of the planning area.

10.1 Geography of the Region

The City Guwahati is situated between the mighty river the Brahmaputra and the Shillong Plateau. Surrounded by hills on all sides, three significant hilly regions that is placed in the heart of the city having natural as well as historical and religious importance like Nilachal, Chitrachal, and Narakasur hills. The mighty Brahmaputra flows through the city, dividing the Guwahati city into two parts- North Guwahati and South Guwahati. The city is blessed with an abundance of resources which includes forest reserves, minerals, rivers, and fertile land. The River Brahmaputra is the main river of Guwahati. One of the largest rivers in the world, the Brahmaputra River is about 2900 km long and is a transboundary and braided river. While most of the rivers in India are considered female rivers, the Brahmaputra is a male river. There are several reserved forests in Guwahati. The reserved forests within the limits of GMPA are Hengrabari, Phatasil, and Jalukbari. Where small portion of Rani and Garbhanga reserved forests are also located within GMPA. Guwahati also has mineral reserves

in the form of oil and natural gas. Tea also occupies an important place in the resources of Guwahati. Guwahati has a subtropical climatic condition. The city experiences a moderate climate throughout the year. Summer in Guwahati is accompanied by high humidity, the monsoon months experience heavy showers while winters are mild and pleasant. The temperature ranges between 10 to 32 degrees Celsius. Guwahati is known to receive heavy Monsoon showers. The annual rainfall in Guwahati is 1751.8 mm with an average relative humidity of 72%. Rainfall records show a decreasing trend towards the east and west of Guwahati city. The average rainfall is 146 mm. The months of March, April, and May constitute the pre-monsoon season. The nor westers locally called Bordoichilla appears during that period. Rainfall ranges between 58 mm and 243 mm. With the onset of monsoon in early June, heavy rainfall occurs. Widespread low clouds and high humidity together maintain almost uniform temperatures over the area. The average annual rainfall during the period is 326 m.

The following figure 10-1 represents the physiographic features present in Guwahati. As it can observe the hill locks are located within the core city region. In Southeast and Southwest area and the availability of water bodies which includes river Brahmaputra and all the other existing wetlands.



10.2 Rivers

Urbanization has got its own advantages and disadvantages. The main advantage is that it provides scope for provision of common infrastructure facilities. The main disadvantage is that it creates more strain on the natural resources (including land and waterbodies). The environmental consequences of urban growth are considerable. Cities are prolific users of natural resources and generators of wastes. The urban ways of living contribute to relatively more pressure on resources. Migration of people to riverbank creates scattered clusters of settlement which puts enormous pressure on the available water resources. Some of the issues will be water scarcity and water pollution, air pollution, climate and Heat Island Effect, poor management of solid wastes, urban congestion etc. in the system.

Guwahati, the capital city of Assam and gateway of North East India possess a unique natural drainage network. The city extends along the bank of Brahmaputra in a linear shape and is bounded by the river on the north and a series of hills along the remaining periphery, except for a portion in the west where a natural wetland, the Deepor Beel is situated. On the south bank of the Brahmaputra there are as many as five tributaries—Bharalu, Mora Bharalu, Basistha, Khanajan and Basistha Bahini. Among them, Bharalu (the upstream portion of which is called Bahini) and Basistha run through the city. The Bharalu channel has its outfall in Brahmaputra while Basistha flows to Deepor Beel through Mora Bharalu channel, which is connected to Brahmaputra through Khanajan. Bonda Jan in the east of the city was connected with Silsako Beel but presently Bondajan is an independent waterbody by shrinking over the period of time and not connected with Silsako Beel throughout the year.

Description of the course and Length of Bharalu, Bahini, Basistha, Mora Bharalu and Khanajan

Table 10-1: River Description of GMPA

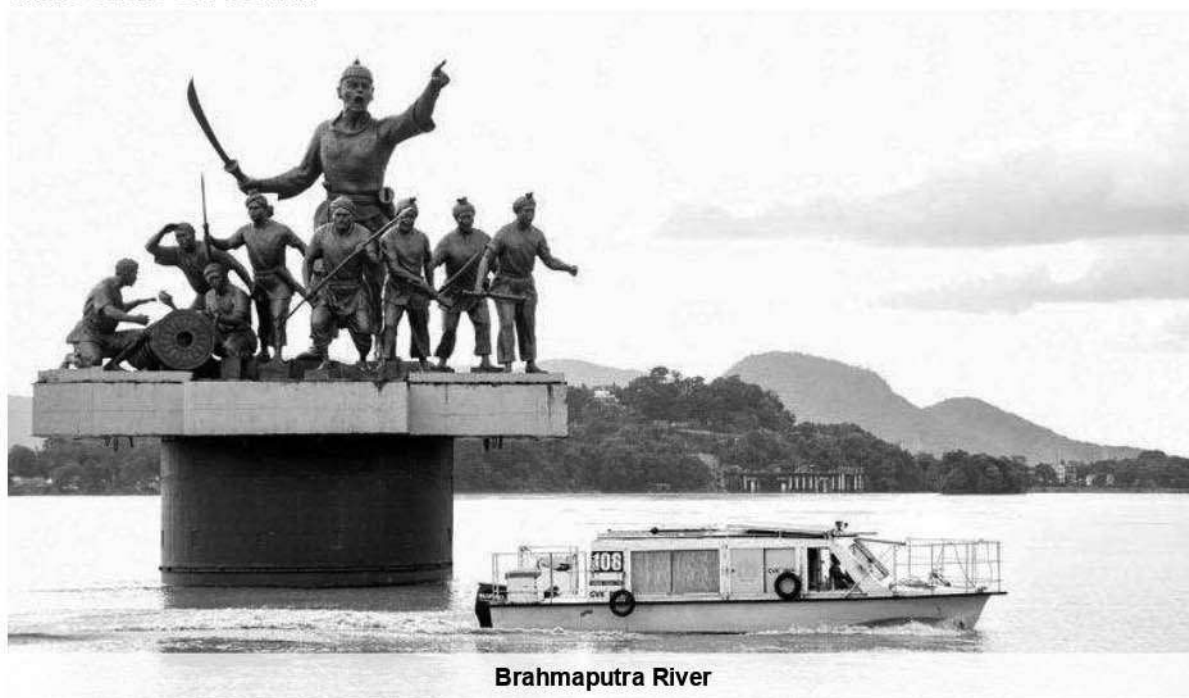
River	Description of the course of river	Length (km)	Total Length(km)
Bharalu	Split from Bahini at the Indian Oil Refinery drain to Bharalmukh where it drains into Brahmaputra River	7	16
Basistha Bahini	Split from Basistha to its downstream point at the Indian Oil Refinery drain where it is known as Bharalu	9	
Basistha	From its origin in Meghalaya Hills to confluence point with Dead Bharalu or Mora bharalu	19	27

	After the confluence point with the Mora Bharalu up to Deepor Beel.	8	
Mora Bharalu (Dead Bharalu) Khanajan	Between Bharalu and Basistha		13
	Between Deepor Beel and Brahmaputra River		7

(Source: City Sanitation Plan, Conservation of River Bharalu, DPR, Pollution Control Board, Assam)

10.2.1 The Brahmaputra River

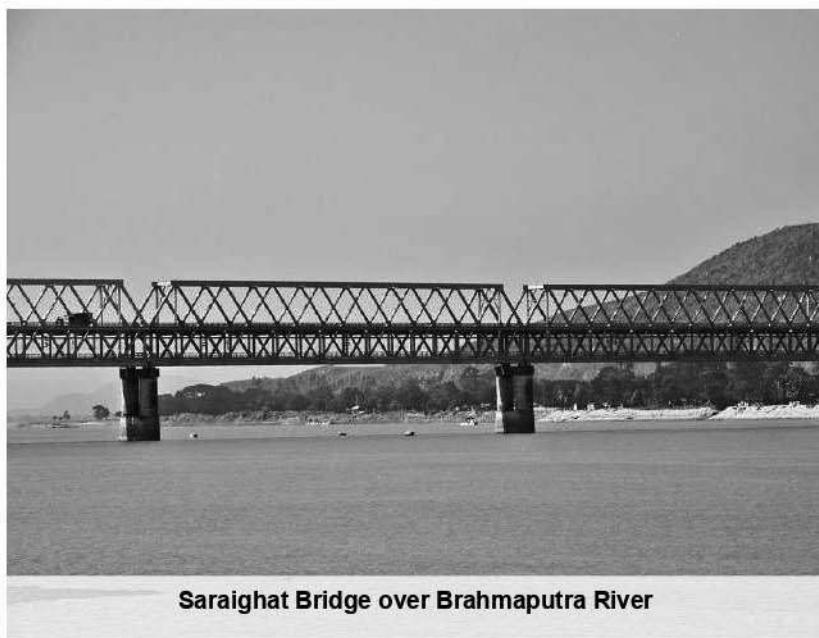
The river originates from the Kailash ranges of Himalayas at an elevation of 5300 M. After flowing through Tibet it enters India through Arunachal Pradesh and flows through Assam and Bangladesh before it joins Bay of Bengal. The average width of Brahmaputra is 5.46 Km. The average annual discharge is about 20,000 cumec and average dry season discharge is 4,420 cumec. The river slope is very steep till it enters India. A drop of about 4800 M is achieved in a length at about 1700 Km in China (Tibet). This average slope of about 2.82 m/Km gets reduced to about 0.1m/Km in Assam valley. Due to this sudden flattening of river slope, the river becomes braided in nature in the Assam valley. During its course in Assam valley from Kobo to Dhubri the river is joined by about 20 (twenty) important tributaries on its North bank and 13 (thirteen) on its South bank. Joining of these tributaries bringing high sediment load activates braiding. All the tributaries of the valley area are rain fed and foam up with rain. The precipitation here is mainly due to South West monsoon. Heavy precipitation occurs here from May to September. It travels a distance of 750 KM throughout the entire state of Assam.



Brahmaputra River

The Brahmaputra River basin hosts very rich and unique biodiversity. The whole of north-eastern region is a globally recognized bio-diversity hot spot. In the Indian territory the total forest cover of the Brahmaputra basin is 1,14,894 sq. km. which is 54% of the total basin area. In the distribution of forest cover among 6 states in Brahmaputra basin, Arunachal Pradesh tops the list with 82.8% forest cover, but it is sad that the highest number of hydro-electric dams are planned in this state inviting disastrous impacts for the biodiversity, forests, people, and environment. The tally of rest of the five states is as follows – Nagaland (68.9%), Meghalaya (63.5%), Sikkim (38.1%), West Bengal (21.4 %) and Assam (20.6 %). Brahmaputra is a huge river. In some places of Assam it is close to 10 kilometres wide and looks more like a sea than a river.

The Brahmaputra is very wide and braided in the city Guwahati. Sunrise and Sunset at the river are worth watching at many places across Assam. Guwahati being present very close to Brahmaputra provides great views of the river which are worthy to watch.

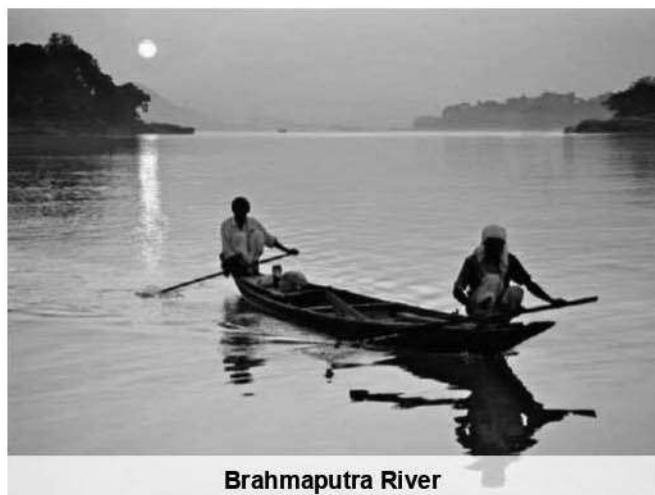


Saraighat Bridge over Brahmaputra River

Brahmaputra river basin is known to be very prone to flood and erosion and these two hazards have led to many problems in the basin. In India, out of the eight north-eastern states, Assam faces the most severe brunt of flood and erosion. Both flood erosion has been severely affecting the economy as well political, social, and cultural milieu of Assam.

10.2.1.1 Current Scenario

Brahmaputra River with Assam is almost 700 km. long with more than 100 tributaries. Brahmaputra, the major natural feature in Guwahati, has total length of 28.67km in Guwahati and total area 49 sq.km. The Brahmaputra River at Guwahati is one of the main tourist spots of the city. The Brahmaputra offers tourist an exciting experience. The river



Brahmaputra River

provides the tourists a majestic view with greenery at all the sides. For the length of the river Brahmaputra serves as an important inland waterway. Brahmaputra is used for inland navigation.

10.2.1.2 Polluted River Stretch

The length of the polluted stretch of Brahmaputra river is 373 kms out of 750 kms of the total stretch (Figure 10-2) and the stretch identified as polluted is from Bogibeel to Sualkuchi. The entire stretch of Brahmaputra river covers eleven (11) monitoring locations under NWMP. However, the BOD level was found to be exceeding 3mg/L in only six (06) monitoring stations on few occasions.

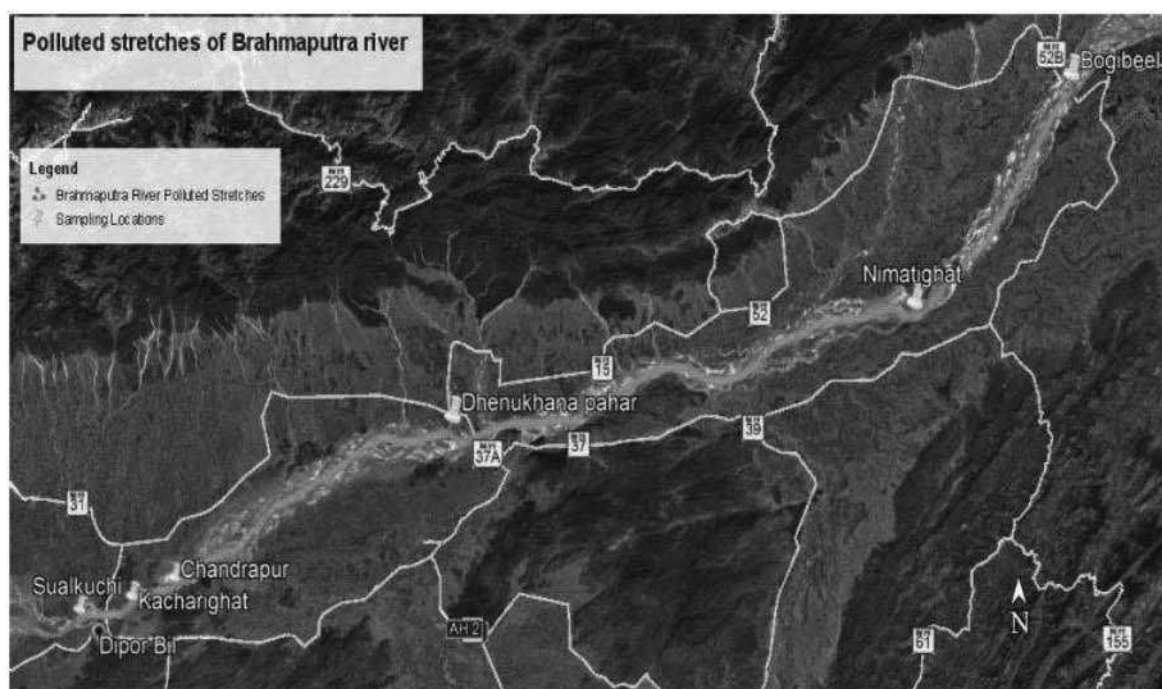


Figure 10-2: Polluted Stretches in Brahmaputra River

10.2.1.2 Identification of Major Locality around riverbank

Guwahati is one of the major Cities located on the bank of the Brahmaputra River. The approximate population of the Guwahati is 11.5 lakh as per Census 2011. The major localities identified in and around the catchment areas of polluted stretch of Brahmaputra River at down streams apart from Guwahati are

a) Bogibeel: Dibrugarh is the major town located in the bank of river Brahmaputra at around 18 kms upstream of the sampling station. Medium sized villages viz: Bogibeel gaon, Lengapathar gaon, Hapekheti gaon and Walkhabi gaon no.1 of Disbrugarh district and Kareng gaon, Garmara Chapori, Dambuk kalabari, Merchapori and Amguri bali of Dhemaji district under Sissiborgaon tehsil are situated in the catchment of the Bogibeel polluted stretch.

b) Nimatighat: The nearest major town from the sampling point is Jorhat. However, the Nimatighat stretch is located around 15 kms upstream from the Jorhat town. The name of the villages identified in the catchment of the Bogibeel polluted stretch are Kumar gaon, Makori khuti gaon and Kobortta gaon.

c) Dhenukhana Pahar: Tezpur is the major town belonging to Sonitpur district is located in the Bank of the river. d) Chandrapur: No major towns are located near the sampling point. However, few medium sized villages viz: Chandrapur, Tatimara and Barchapori are situated in the catchment of the polluted stretch.

d) Kacharighat: The localities identified to be situated in the catchment area are Fancy Bazar, Pan Bazar and Kachari which are localities of Guwahati city and Rajaduar and Madhyam Khanda under North Guwahati circle. There are only few permanent human settlements in the Fancy Bazar, Panbazar and Kachari area as these places are busy commercial markets and considered as central locations of various shopping hub.

e) Sualkuchi: Sualkuchi is the only major town located nearby the sampling station. Localities such as Kacharighat and Sualkuchi are located within GMPA and these areas are being considered for further analysis.

10.2.1.3 Quantity of Sewage generated

There are no existing STPs located in the towns and cities. The aggregate sewage generated from the localities and towns are 1479.6 KLD at Kacharighat polluted stretch and 1500.96 KLD at Sualkuchi polluted stretch. (Source: Action plan for Brahmaputra River, PCB, Assam)

10.2.1.4 Sewerage Treatment Proposal

As per the survey done, one (01) number of STP has been proposed at Guwahati town in consultation with the District Administration.

Table 10-2: Sewerage Generation Calculation

Sr. no.	Area	Population	Water Consumption (KLD)	Sewage Generation (KLD)	No. of STPs proposed	Existing Treatment capacity (KLD)	Gaps in KLD
1.	Fancy Bazar, Panbazar and Kachari, Rajaduar, Madhyam Khanda at Kacharighat stretch	13700	1849.5	1479.6	0	Nil	1479.6
2.	Sualkuchi at Sualkuchi stretch	13898	1876.2	1500.96	0	Nil	1500.96
Total		27,598	3725.7	2980.56	0	Nil	2980.56

(Source: Action plan for Brahmaputra river, PCB, Assam)

10.2.1.5 Water quality of polluted stretches of Brahmaputra River

The detail analytical data of the polluted stretches of Brahmaputra River for the month of March 2020 (Kacharighat and Sualkuchi) are presented further in Table 10-3.

Table 10-3: River Water Quality Parameter

SI No.	Parameter	Kacharighat (March 2020)	Sualkuchi (March 2020)
1	D.O. (mg/L)	10.4	9.0
2	pH	8.0	7.9
3	Cond (μ S/cm)	186	146
4	BOD (mg/L)	2.3	1.6
5	COD (mg/L)	7.8	7.8
6	NO ₃ - N (mg/L)	1.5	2.0
7	TSS (mg/L)	52	68
8	Turbidity (NTU)	05	05
9	p-Alkalinity (mg/L)	Nil	Nil
10	m-Alkalinity (mg/L)	42	50
11	Hardness (mg/L)	68	46
12	Calcium as CaCO ₃ (mg/L)	50	30
13	Magnesium as CaCO ₃ (mg/L)	18	16
14	Chloride as Cl (mg/L)	10	08
15	Total Iron (mg/L)	0.19	0.26
16	Copper (mg/L)	BDL	BDL
17	Arsenic(mg/L)	BDL	BDL

(Source: Action plan for Brahmaputra river, PCB, Assam)

It was observed that the Biochemical oxygen demand (BOD) value was found to be within the permissible limit during the last two years at all locations of Brahmaputra River. However, copper and arsenic content in the surface water of the river is found below detectable limit (BDL). Based on water quality monitoring reports of the last 2

years, it is observed that the river Brahmaputra does not have polluted stretches at present. Since the river has high volume and discharge, it has the phenomenon of self-purification, which is constantly taking place, and hence no actions for rejuvenation of the mentioned river stretches of Brahmaputra River may be required.

10.2.1.6 Drains contributing to pollution

The city of Guwahati lacks overall proper drainage system. The drains present along roads are not capable enough to handle excessive flow of water during monsoon season. The entire Guwahati Metropolitan Area is divided into seven drainage basins, through which all the wastewater of the city is drained into the river Brahmaputra either directly or through various drainage channels and reservoirs indirectly.

The river Brahmaputra as already mentioned is mainly responsible for carrying all the foul waters discharged by the city. Most of the storm water from the area south of the river Brahmaputra is carried away through the rivers Bharalu and Basistha flowing inside the city to Deepor beel situated in the south-west part of Greater Guwahati city and finally discharged to the river Brahmaputra through Khanajan river.

Poor drainage in Guwahati is an age-old problem. There are two major drains originated at fancy bazar and Sukleswar temple that directly discharges in the Kacharighat sampling point. At Sualkuchi there are no major drains connected to this stretch of the river. Most of the households have individual drainage or drains of natural origin which are responsible for evacuation of sewage. Moreover the discharges from the open drains gets absorbed by the soil before making their way to the river.

Table 10-4: Analysis report of the major drains contributing to pollution in Brahmaputra river at Kacharighat (March 2020)

SI No.	Parameter	Water from drains near Sukleswar temple Before confluence with Brahmaputra	Water from drain at Fancy Bazar (behind MMCH) before confluence with Brahmaputra
1	D.O. (mg/L)	1.4	1.2
2	pH	7.6	7.1
3	Cond (μ S/cm)	270	364
4	BOD (mg/L)	16.6	18.4
5	COD (mg/L)	44.2	48.6
6	NO ₃ - N (mg/L)	2.4	2.8
7	TSS (mg/L)	54	66
8	Turbidity (NTU)	08	08
9	p-Alkalinity (mg/L)	Nil	Nil
10	m-Alkalinity (mg/L)	114	136
11	Hardness (mg/L)	124	128

12	Calcium as CaCO ₃ (mg/L)	58	96
13	Magnesium as CaCO ₃ (mg/L)	24	32
14	Chloride as Cl (mg/L)	18	20
15	Total Iron (mg/L)	0.36	0.33
16	Copper (mg/L)	0.004	0.006
17	Arsenic(mg/L)	0.004	0.005

(Source: Action plan for Brahmaputra River, PCB, Assam)

Table 10-5: Flow Details of the Major drains out falling in Brahmaputra River

Polluted Stretch	Source	Type of liquid waste	Flow details of the major drains/ outfalls (m ³ /s)	Flow details of the major drains/ outfalls (KLD)
Major Drains/ Outfall of Brahmaputra river at Kacharighat	Drain near Sukleswar temple before confluence with Brahmaputra river	Commercial & Domestic	0.0076	656
	Drain at Fancy Bazar (behind MMCH) before confluence with Brahmaputra	Commercial & Domestic	0.0051	440

(Source: Action plan for Brahmaputra River, PCB, Assam)

10.2.1.7 Ground Water Quality

The water quality of Assam is found to be well within the permissible limit for drinking, irrigation and industrial purposes. Slightly higher content of iron in some sporadic patches of the area are observed, hence water needs to be treated before being used for drinking purpose. Also fluoride content is found to be exceeding permissible limit in few pockets of the state. As per the data generated from PCBA, the ground water quality around the catchment area of polluted stretch of the Brahmaputra River is found to be within the permissible limit and safe for domestic and irrigation purposes.

Table 10-6: Ground Water quality of catchment area of Brahmaputra River

SI No.	Parameter	Kacharighat	Sualkuchi
1	D.O. (mg/L)	10.4	9.0
2	pH	7.1	7.1
3	Cond (µS/cm)	148	148
4	BOD (mg/L)	1.4	1.4
5	COD (mg/L)	5.3	5.3
6	NO ₃ - N (mg/L)	2.4	2.4
7	TSS (mg/L)	08	08
8	Turbidity (NTU)	02	02
9	p-Alkalinity (mg/L)	Nil	Nil
10	m-Alkalinity (mg/L)	94	94
11	Hardness (mg/L)	44	44
12	Calcium as CaCO ₃ (mg/L)	32	32
13	Magnesium as CaCO ₃ (mg/L)	12	12

14	Chloride as Cl (mg/L)	10	10
15	Sulphate as SO_4^{2-} (mg/L)	7.4	7.4
16	Phosphate as PO_4	0.08	0.08
17	Total Dissolved Solids (mg/L)	96	96
18	TFS (mg/L)	24	24
19	Fluoride (mg/l)	0.036	0.036
20	Boron (mg/l)	0.021	0.021
21	Total Iron (mg/L)	0.003	0.003
23	Copper (mg/L)	BDL	BDL
24	Arsenic (mg/L)	BDL	BDL

(Source: Action plan for Brahmaputra River, PCB, Assam)

10.2.1.8 Key Issues:

Guwahati's role in Brahmaputra's pollution is undeniable and the city has been a constant source of all sorts of pollution, causing the river significant harm. A Central Pollution Control Board (CPCB) study in 2012 found out that the faecal coliform bacteria level in the river water in Guwahati was 3,000 more probable number (MPN) per 100 millilitres, much more than the 2,500 that is the usual norm. The bacteriological oxygen demand (BOD) in Brahmaputra in Guwahati was worse than any tributaries. With 400 MPN per 100 ml was worse than Haridwar's 268 per 100 ml in one of the most polluted areas of the river Ganga. Despite being Assam's primary economic hub, Guwahati lacks a single stated-owned sewage treatment plant (STP), making matters worse for the river. River clean up activities, though conducted under the Guwahati civic body's watch can do little to have any effect on the river as the amount of pollution is unmatched.

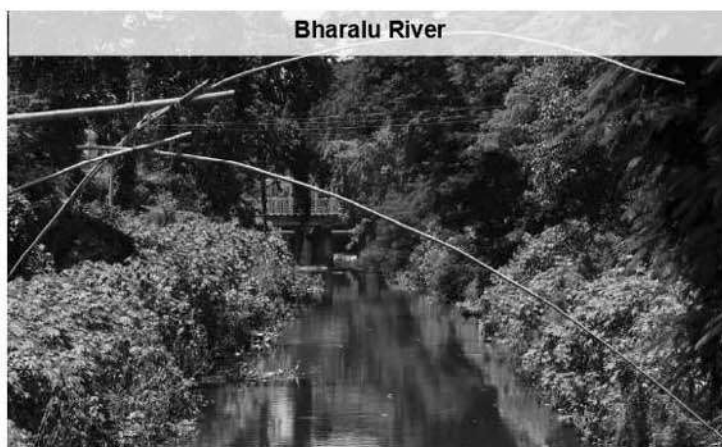
During monsoon season, the river Brahmaputra flows over the danger level and the low-lying areas of Guwahati City face problems of water logging and floods. The feeder drains to the main channels run overflowing, and because of siltation problem of drains, the carrying capacity is also reduced significantly.



Figure 10-3: River Brahmaputra and Guwahati City During Heavy Rainfall

10.2.2 Bharalu River

Guwahati straddles the valley of the river Bharalu, a small tributary of the river Brahmaputra. Bharalu River rises as a small stream from the southern range of Khasi Hills and flows through the city gaining momentum in width and depth; and ultimately joining the



Brahmaputra. The river is a non-perennial one. Initially Bharalu River received perennial flow from Bahini River which originates from Khasi Hills of Meghalaya at Umtyrnga and travels a distance of 9.29 Km before confluence with Bharalu River at Jonali point. The width of the River is on an average 14 meters. Since last fifteen years (15) approx. the natural flow of Bahini River has been totally blocked at Natun Bazar area of Basistha Chariali locality with the help of sluice gate. The Bahini river then flows through Lalmati area near Water Resource department where it meets Basistha river and then finally travels as Basistha Bahini River finally to confluence with Deepor Beel. Bahini River from Bakrapara area in Basistha Chariali now becomes a sewerage drain as the natural flow is obstructed at Natun bazar area. It then travels below NH at Beltola and through major areas like AG office Road, Krishnapur, Saurabh Nagar, Rukminigaon, Downtown area, Ganeshguri, Hengerabari, Zoo Road and finally confluences with Bharalu River at Jonali point carrying all the city sewage including commercial sewage. There is no natural flow of the river at present and only the domestic sewage and commercial sewage are being carried away by the river. It is also observed that the river banks are being encroached specially from Sarabbhati area to the confluence point and hence at many places it is becoming narrower as a result of encroachment. The total catchment area of the Bharalu is about 120 sq. km. which is almost equally divided between the hill region and the plains. It is estimated that the river drains an area of 10.94 sq. km. of the city. The catchment area has seen a very rapid urbanisation in recent years and the river has detoured to a large extent due to unabated encroachment and ever-increasing dumping of garbage into it. The velocity of flow in Bharalu River is estimated to be 1.07-1.37 m/sec. The Flood Control and irrigation Department of the Govt. of Assam has erected a sluice structure near

the Pragjyotish College at Bharalumukh to regulate the discharge level, particularly to stop reverse flow from the Brahmaputra during high floods.

10.2.2.1 Polluted River Stretch

The length of the polluted stretch of Bharalu River is 6.20 KM with an area of 109 sq.km. The stretch identified as polluted is from Jonali point to Bharalumukh. The encroachment on the river banks are spreading due to which the width of the river is becoming narrower and shallower.

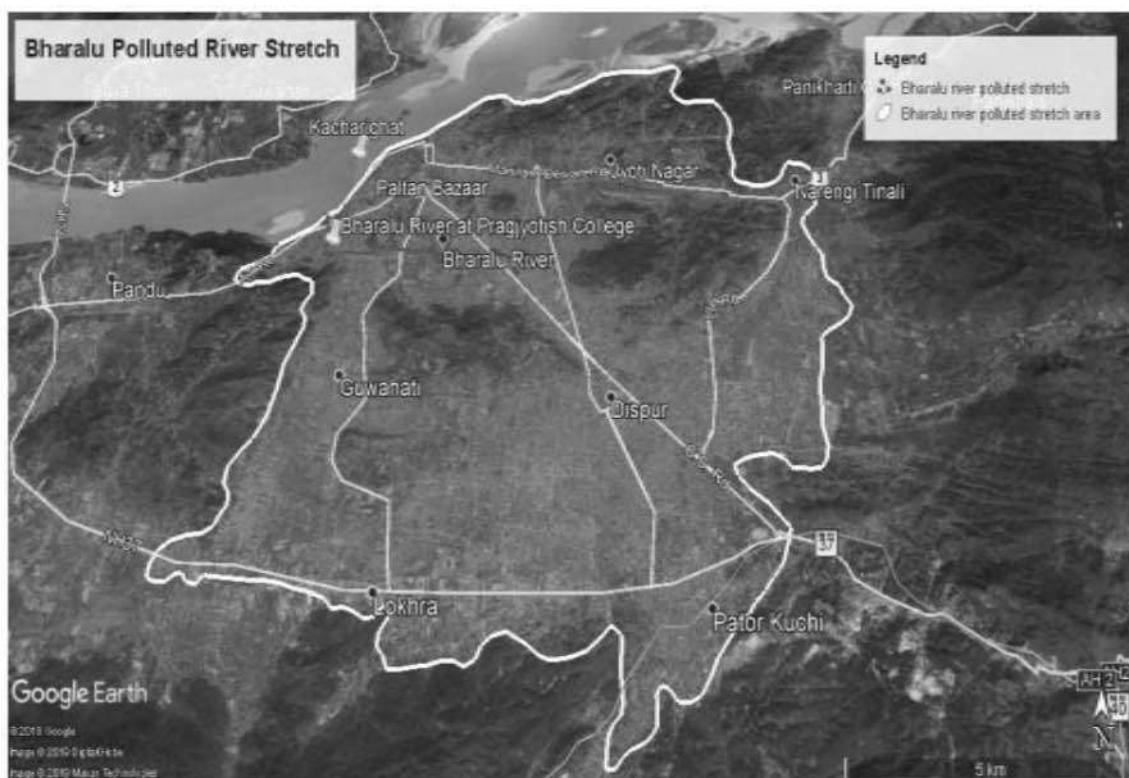


Figure 10-4: Map showing the polluted river stretch of Bharalu river (Source: Action Plan for Bharalu River, PCB Assam)

10.2.2.2 Identification of Major Locality around riverbank

Guwahati is the major city located on the bank of the Bharalu river. The approximate population of the Guwahati (Metro) is 655000 as per Census 2011 in the demarcated catchment area of Bharalu river including the floating population. The major localities identified in and around the catchment areas are Tarun Nagar, Anil Nagar, Nabin Nagar, Bhangagarh, Ulubari, Sarabbhatti, Bishnupur, Athgaon, Fatashil Ambari, Kumarpara and Bharalumukh.

10.2.2.3 Water Quality of the river stretch*Table 10-7: Analysis of Surface water quality of Brahmaputra*

SI No.	Parameter	Value
1	D.O. (mg/L)	Nil
2	pH	7.3
3	Cond (μ S/cm)	542
4	BOD (mg/L)	54
5	COD (mg/L)	98
6	NO ₃ - N (mg/L)	2.6
7	TSS (mg/L)	118
8	Turbidity (NTU)	6
9	p-Alkalinity (mg/L)	Nil
10	m-Alkalinity (mg/L)	74
11	Hardness (mg/L)	108
12	Calcium as CaCO ₃ (mg/L)	74
13	Magnesium as CaCO ₃ (mg/L)	34
14	Chloride as Cl (mg/L)	52
15	Total Iron (mg/L)	0.58
16	Copper (mg/L)	0.008
17	Arsenic(mg/L)	0.01

(Source: Action Plan for Bharalu River, PCB Assam, 2019)

The above data indicated that the BOD load is above 3 mg/l on all the occasion. This is due to the discharge of untreated sewage directly into the river.

10.2.2.4 Drains contributing to pollution

There were almost 39 outfalls identified in the entire stretches of Bharalu River from its origin at Jonali point up to Bharalumukh and these outfalls are either domestic or commercial. Besides, there are many small household drains which discharges the waste water directly in to the Bharalu River.

Table 10-8: Analytical data of the drains out falling in Bharalu River

Source	D.O. (mg/L)	pH	Cond(µS/L)	BOD(mg/L)	COD(mg/L)	NO ₃ -N (mg/L)	TSS (mg/L)	Turbidity (NTU)	p-Alkalinity (mg/L)	m-Alkalinity (mg/L)	Total Hardness (mg/L)	Calcium as CaCO ₃ (mg/L)	Magnesium as CaCO ₃ (mg/L)	Chloride as Cl ⁻ (mg/L)	Sulphate as SO ₄ ²⁻ (mg/L)	Phosphate as PO ₄ (mg/L)	TKN(mg/L)	NH ₄ -N (mg/L)	Total Dissolved Solids (mg/L)	TDS (mg/L)	Fluoride (mg/l)	Boron (mg/l)	Na (mg/L)	K (mg/L)	T-Fe (mg/L)	Lead as Pb (mg/L)	Zinc as Zn (mg/L)	Copper as Cu (mg/L)	Chromium as Cr(Ⅲ) (mg/L)	Nickel as Ni (mg/L)	Cadmium as Cd (mg/L)	Mercury as Hg (mg/L)	Arsenic as As (µg/L)	Total Coliform (MPN/100ML)	Faecal Coliform (MPN/100ML)
Water from refinery located area drain before confluence with Bharalu river at Jonali	NIL	7.3	585.0	56.0	146.8	2.8	126.0	8.0	NIL	284.0	182.0	122.0	60.0	62.0	38.0	1.4	1.4	13.6	4.2	378.0	92.0	0.56	0.032	48.8	15.9	0.58	0.022	0.058	0.010	BDL	BDL	BDL	0.010	95000	7500
Water from drain at Jonali before confluence with Bharalu river.	NIL	7.5	594.0	54.0	142.2	3.0	136.0	12.0	NIL	286.0	178.0	116.0	62.0	64.0	28.4	1.9	0.59	14.0	4.4	382.0	94.0	0.59	0.030	52.6	19.4	0.66	0.024	0.056	0.008	BDL	BDL	BDL	0.008	110000	21000
Water from drain after confluence with Bharalu River at Jonali	NIL	7.3	634.0	58.0	156.4	3.3	120.0	10.0	NIL	298.0	200.0	144.0	56.0	60.0	36.6	2.5		13.8	4.2	410.0	98.0	0.56	0.034	58.6	18.2	0.74	0.026	0.062	0.006	BDL	0.004	0.002	BDL	29000	21000
water from drain before confluence with Bharalu river at Uluberi Mazor	NIL	7.4	653.0	54.0	152.6	3.1	128.0	8.0	NIL	320.0	216.0	144.0	72.0	72.0	31.3	2.1		13.4	4.0	422.0	102.0	0.54	0.028	52.8	16.4	0.56	0.022	0.054	0.010	BDL	BDL	BDL	0.008	5300	3600
Water from Sarabthati drain before confluence with Bharalu river at Sarabthati	NIL	7.4	584.0	56.0	150.8	2.8	136.0	10.0	NIL	224.0	174.0	112.0	62.0	60.0	38.2	2.1		13.6	4.1	374.0	92.0	0.58	0.0	58.2	14.6	0.62	0.028	0.066	0.010	BDL	BDL	BDL	0.010	21000	15000
Water from Bishnupur drain after confluence with Bharalu river at Bishnupur	NIL	7.4	534.0	60.0	144.8	1.7	130.0	6.0	NIL	256.0	164.0	102.0	62.0	56.0	26.8	1.5		13.8	4.2	344.0	84.0	0.52	0.0	49.3	17.2	0.58	0.026	0.058	0.008	BDL	0.004	0.004	BDL	110000	21000

(Source: Action Plan for Bharalu River, PCB Assam, 2019)

Table 10-9: Industrial details as per the following of Bharalu river at Kacharighat polluted stretch

Sl. No.	Name of the Industry	Category	Total Water Consumption (KLD)		Waste water generation in KLD	ETPs
			GW	Supplied Water		
1	Guwahati Refinery, IOCL	17 -Category (Petroleum Refinery)	NIL	11283	5032	Installed; as per records 5032 KLD of Effluent is treated and reused.
2	Diesel Shed, New Guwahati	RED(Railway Locomotive workshop)	1.1	NIL	1.1	Functional
3	Guwahati Medical College & Hospital, Bhangagarh, Guwahati	RED	NIL	350	280	STP Functional
4	Kiranshree, Athgaon.	Green	2	NIL	1.5	Functional
5	Monsoon Polymers, City Complex, Kalapahar.	orange	5	NIL	4	Functional
6	Assam Dyeing Works, Cycle Factory, Kalapahar.	red	2.5	NIL	2	Functional
7	Panacea Diagnostic Centre, Rajgarh, Ghy.	orange	1	NIL	0.8	Functional
8	Hotel Asian Palace, Ulubari, Ghy	Green	4	NIL	3.2	Functional
9	Sanjay Products, Fatashil Ambari.	orange	1.5	NIL	1	Functional
10	Goenka Nursing Home, Bharalumukh, Ghy.	orange	30	NIL	30	Functional
11	Kumar's Nursing Home, Kumarpara	orange	10	NIL	10	Functional
12	Rapid Diagnostics, Sarabbhati	orange	0.2	NIL	0.16	Functional
13	Rosa Restaurant,	Green	3	NIL	2.4	Not installed. Direction issued
14	Makhan Bhog, Ulubari.	Green	5	NIL	4.5	Functional
15	Woodland Marriage Hall, Ulubari.	Green	5	NIL	4.5	Not installed. Direction issued
16	Signature Estate (Assam Plywood)	red	120	NIL	100	STP Provided
17	RK Life Services Pvt. Ltd. Apollo Clinic, Bora Service.	orange	1	NIL	1	Functional
18	Nemcare Hospital Pvt. Ltd. Bhangagarh, Ghy.	orange	50	NIL	45	Functional
19	Nemcare Hospital, Bhangagarh, Ghy	orange	60	NIL	52	Functional
20	Pulse Diagnostic, Bhangagarh, Ghy.	orange	1	NIL	0.8	Functional
21	Primus Diagnostic, Bhangagarh, Ghy.	orange	1	NIL	0.8	Functional

22	Alcare Diagnostic, Lalganesh, Guwahati-34	orange	3	NIL	2.4	Functional
23	Orthodontic Clinic, Bhangagarh, Ghy.	orange	1	NIL	0.8	Functional
24	Health Care Diagnostic, Bhangagarh, Ghy.	orange	0.6	NIL	0.5	Functional
25	Aruna Memorial Hospital, Bhangagarh, Ghy.	orange	15	NIL	12	Functional
26	Apex Diagnostic, Bhangagarh, GMCH Road, Royal Market, Guwahati – 05	orange	1	NIL	0.8	Functional
27	K.N. Baruah (Bids), Roodraksh Mall, Ghy	orange	0.4	NIL	0.3	Functional
28	Midland Hospital, RG Baruah Road, Ghy.	orange	10	NIL	9	Functional
29	Exotica Greens	orange	50	NIL	45	STP Provided
30	Hariyana Bhawan	Green	5 (During Marriage Party)	NIL	5	Not installed. Direction issued
31	East India Haematological Laboratory	Orange	0.4	NIL	0.3	Functional
Total			389.7 KLD	11633 KLD	5652.86 KLD	

(Source: Action Plan for Bharalu River, PCB Assam, 2019)



Figure 10-5: Existing Scenario of Bharalu River

10.2.2.5 Flow details of the major drains contributing to river pollution*Table 10-10: Flow Details of the Major drains out falling in Bharalu River*

Sl. No.	Major Drains/Outfall of the Bharalu River	Type of liquid waste	Flow details of the major drains/ outfalls (m ³ /s)	Flow details of the major drains/ outfalls (KLD)
1	Refinery locoshed area drain before confluence with Bharalu river at Jonali	Commercial & Domestic	0.22	19.1
2	Drain at Jonali before confluence with Bharalu river.	Domestic	0.05	4.32
3	Drain after confluence with Bharalui River at Jonali	Domestic	0.03	2.6
4	Drain before confluence with Bharalu river at Ulubari Mazar	Domestic	0.18	15.56
5	Sarabbhati drain before confluence with Bharalu river at Sarabbhati	Domestic	0.14	12.1
6	Bishnupur drain after confluence with Bharalu river at Bishnupur	Domestic	0.09	7.8
7	Other minor drains	Domestic	Cumulative flow	10.0 (Approx.)
Total				71.48 MLD

*(Source: Action Plan for Bharalu River, PCB Assam, 2019)***10.2.2.6 Sewage generation from the towns located on the banks of the polluted river**

The main contributor of pollution in the river is municipal sewage besides commercial and industrial wastes. There are no treatment systems for the sewages at present. Drains are directly connected to the Bharalu river there by finding its way to Brahmaputra River without treatment. Moreover, Sewage treatment facility has not been set up yet in Assam.

10.2.2.7 Number of Sewage treatment plants present and treatment capacity, and gaps

There is no sewage treatment plant at present. The gaps in sewage treatment capacity are 71 MLD at present and up to 2030 it is estimated to be 75 MLD

10.2.2.8 Drainage system/ sewerage network present/proposed by the administration

There is no sewerage system at present. In this project 3 numbers of STPs along with interceptor drains for collection of the sewage of the basin has been proposed. All the sewage of the catchment area of the river shall be collected by interceptor drains and shall be treated in the proposed STPs.

10.2.2.9 Ground Water Quality

The water quality is found to be well within the permissible limit for drinking, irrigation and industrial purposes. Due to slightly higher content of iron in some sporadic patches of the area and fluoride content exceeding permissible limit in some pockets in and around Guwahati City, water needs to be treated before being used for drinking purpose.

10.2.2.10 Ground water Quality of Shantipur area under National Water Quality Monitoring Programme (Catchment of River Bharalu)

Table 10-11: Analysis report of Ground water from Shantipur area- May 2019 (Under NWMP)

Sl. No.	Parameter	Value
1	pH	6.8
2	Cond (µS/cm)	193
3	BOD (mg/L)	2.7
5	COD (mg/L)	5.4
6	NO ₃ - N (mg/L)	0.7
7	TSS (mg/L)	20
8	Turbidity (NTU)	6
9	p-Alkalinity (mg/L)	Nil
10	m-Alkalinity (mg/L)	84
11	Hardness (mg/L)	62
12	Calcium as CaCO ₃ (mg/L)	40
13	Magnesium as CaCO ₃ (mg/L)	22
14	Chloride as Cl (mg/L)	22
15	Total Iron (mg/L)	0.56
16	Copper (mg/L)	0.006
17	Arsenic(mg/L)	0.004

(Source: Action Plan for Bharalu River, PCB Assam, 2019)

10.2.2.11 Flood Plain Zone along Catchment of River Bharalu

The following are the identified flood prone area for the polluted river stretch

Table 10-12: Flood Plain Areas along Bharalu River

Name of River	Flood plain areas
Bharalu River	Tarun Nagar, Anil Nagar, Nabin Nagar, Bhangagarh, Ulubari, Sarabbhatti, Bishnupur, Athgaon, Fatashil Ambari, Kumarpara and Bharalumukh.

(Source: Action Plan for Bharalu River, PCB Assam, 2019)

10.2.3 Basistha and Basistha Bahini River

Basistha river is a small tributary of the Brahmaputra River which flows through the heart of the city. The river Basistha is often termed as a rivulet as its dimension over the drainage area is meso-level. The area is comprised of a part of the Basistha River continuing from the Basistha temple upto the pilot cut of the river reach near the Fatashil- Katabari region near the NH-37, from where, it joins the Mora Bharalu to form the Pamohi river which ultimately has its outfall in the Deepor Beel. The riverbanks of the Basistha extending from the Basistha temple upto the Fatashil-Katabari region has been exposed to degradation as a result of human out growth over the region, over the past few decades. Moreover, the rapid urbanisation, development of settlements, encroachment over the Meghalaya border region, deforestation and downcutting of hills over the upper catchment area has led to distortion of the natural phenomenon of the river and has destabilised the regime. Most of the city's wastewater, in the form of sanitary sewerage and domestic sewerage together with liquid waste from commercial establishment like hotel/restaurant, hospital/health care units, flows initially through drains and then through tributary rivers in untreated condition and ultimately join the river Brahmaputra. The consequences of these actions are faced by the inhabitants of the study area as the surrounding of the catchment area are rendered dirty and the river is turned into a useless drain. The resultant effect of which, the local inhabitants suffer from periodic artificial flood and the unhygienic condition creates a health havoc amidst the people (Chinmoyee Borpujari, 2015)⁴.

10.2.3.1 The Basistha River and its Course

The Basistha River owes its genesis from the northern part of the East-Khasi Hills district from the Mount Jatorbor peak of Garbhanga Reserve Forest in Meghalaya, at an elevation of 780–638 m above sea level. The Basistha, with its many small tributaries, cuts through a major part of the reserve and initially drains into the Bahini river. Finally, the river drains into Deepor Beel. From Mount Jatorbor peak, it originates as river Barpani and joins the Akhari or Khorupani river on its path. These two rivers Akhari and Barpani forms the physiographic boundary between Kamrup district of Assam and East Khasi Hills district of Meghalaya and extends upto Garhjula hills for 10 kms towards the North-eastern direction. Before reaching the Basistha temple the

⁴ Chinmoyee Borpujari, 2015, Environmental and Social Impacts of River Basistha in Guwahati City, International Journal of Interdisciplinary Research in Science Society and Culture(IJIRSSC)

river travels parallel to the Patalia river. The lower portion of the river (3.5 km), which was about one to three metres wide with a depth ranging from six centimetres in fast flowing parts to 120 cm in the deepest pools. The river flows through southern part of Guwahati City and outfalls at Morabharalu near Katabari. Presently another stream, near Bakrapara, a new stream had been manually diverged towards western direction. The main course of the river Basistha travels from Basistha chariali to 500mtrs towards the west along the NH-37 and turns northward and reaches Hatigaon. From Hatigaon



Figure 10-6: River Basistha

it gradually travels in the west and turns southward direction and reaches Sonaighuli. Earlier the Basistha River from Sonaighuli region flows downstream and diverges into two courses, one travelling westward and reaches the Deepor Beel and another travelling in the northern direction, joins the Bahini river to form the Bharalu river. Presently the Basistha River travels 2 kms south westward from Sonaighuli and near Fatashil Katahbari region turns southwards. This way after crossing, a route of half kilometres it travels along with the Jajoa river in the left and turns westward. Again, surpassing a 500 meter long route, it crosses the NH 37 and travelling along the right side of Sukhoja river forms the Mora-nola. The river flows westward for a distance of 2 kms and combines its course with a stream running from the South Fatashil Reserve Forest of Maligaon in the right and Panchdhara river in the left and flows 4 kms to reach the Deepor Beel. The length of the river from source to its outfall at Deepor Beel is 27 kms.

10.2.3.2 Landuse Pattern around Basistha River

The area has undergone a vast change in landuse pattern over time. The Basistha catchment area changed its nature from a very less populated region in 1901 to a densely populated region in 2011. The city population changed abruptly from 1951 onwards, during this period. Though there is drastic increase in population, and

number of residential houses increased about 15-fold, the area witnessed a little growth in residential area. On the other hand, office industry and commercial areas increased. This indicates increase in economic activity in the area. It may be concluded that maximum utilization of land holdings had taken place during this period. This indicates that the land is not easily available in the plains and alternatively higher reaches of the hills are utilized. With this situation, in near future the nature of construction is bound to change where individual house will be replaced by multi-storeyed buildings.

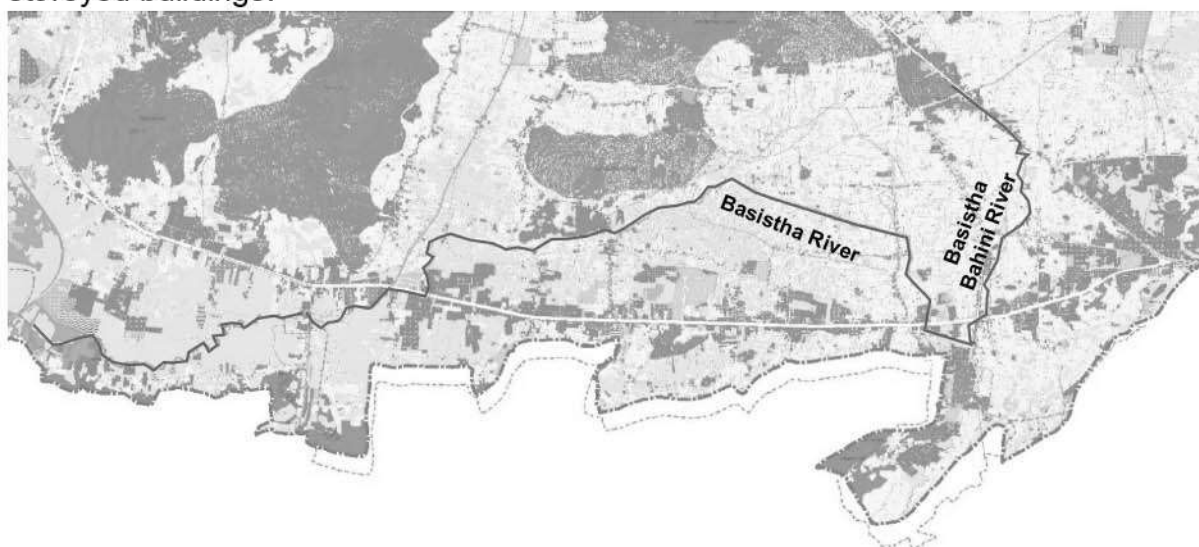


Figure 10-7: Landuse around Basistha and Basistha Bahini River

10.2.3.3 Key Issues in and around Basistha River

Flood and erosion have been a major concerning factor in the Basistha catchment area. The storm water discharge coming from the upstream are a major reason for flood. This is often a situation of artificial flood in the surrounding regions. The networks through which small rivers like Basistha carry water to the Brahmaputra are fragmented. Pollution and improper sewerage block the flow. The city never had a sewage treatment plan. This is the first and foremost reason of flood in the study area. The river, considered sacred by the people, has been narrowed down to a channel by the activity of people living on both its banks. Moreover, the rise of population and habitation over the surrounding area of Basistha River have increased at an alarming rate causing much impact over the resource utilisation and devastation at an accelerating rate. Similar to the flood problem of the Basistha River, the river during its upper course also faces the problem of erosion. However, this problem of erosion in the Basistha catchment area is not given due prominence. The impact of the river over the entire catchment has been acting a serious curse for the people inhabiting

the region. The prime problem of the local inhabitants of the study area is the frequent occurrence of flash floods leading to seasonal relocation. The main causes of artificial flood in the Basistha catchment area, are encroachment by certain people upon hills in the city, dumping of garbage in drains earth-cutting in the hillocks in and around the city, blocking of natural drains by people for building houses and heavy deforestation in the upper reaches increases the siltation of the bed. As a result of this the natural carrying and discharge capacity of the river is reduced, ultimately reducing it to a mere drain. The polluted stretch over the city creates unhygienic condition for the inhabitants. Clogging of the river course by solid waste and debris deposition also becomes a cause of concern in as it decreases the carrying capacity of the river to drain its catchment efficiently during the monsoon or following a major downpour. This causes water logging problem in the riverside areas causing unhygienic conditions for the inhabitants and affecting public health.

The stretch of the Basistha River that flows through the City of Guwahati suffers from severe environmental degradation and continues to impact the health/hygiene of the inhabitants in the surrounding area. There are multiple sources of pollution to the Basistha such as- solid waste, Drainage Channels, local refineries.

10.2.4 Mora Bharalu River

Mora Bharalu is a small channel which is linked with Bharalu and Basistha stream in south and south-eastern part of the city and flows to the Deepor Beel. The story of India's lost rivers goes a long way. A majority of them are nothing but rivulets or small tributaries of major rivers. For instance, River Bharalu and its Rivulet Bahini, which flow through the city of Guwahati in Assam, are live examples. The River Bharalu, after flowing a few kilometres from its origin in the foothills of Meghalaya (the Khasi Hills), bifurcates into two rivulets: the Basistha (which flows towards Deepor Beel, a Ramsar Site) and the Bahini (which flows through the

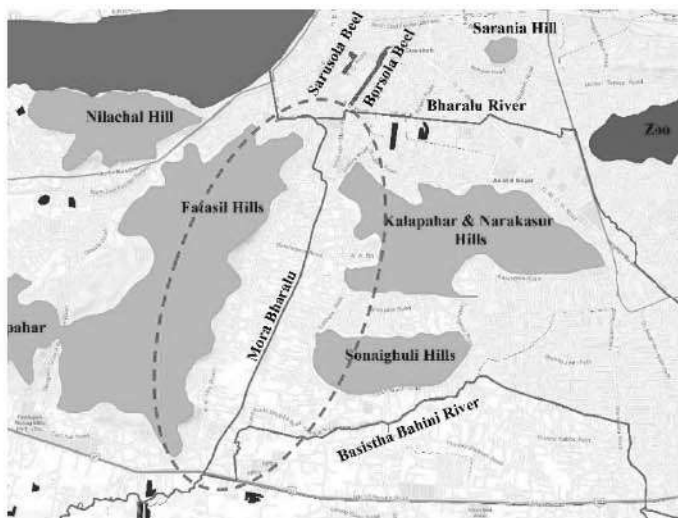


Figure 10-9: Flow of Mora Bharalu through Guwahati City



Figure 10-8: Mora Bharalu River

city of Guwahati and eventually drains into the Brahmaputra). The entire water of the Guwahati city should, ideally, pass through the Bharalu and the Bahini and ultimately fall into the mighty Brahmaputra. However, today, both the Bharalu and the Bahini are reduced to mere 'nallahs' or 'sewers' due to rapid, unplanned and haphazard developmental activities and urbanization processes ubiquitous in the city. Notably, a segment of the water-carrying rivulet in Guwahati is known as 'Mora Bharalu'. In the native Assamese language, 'Mora' means 'Dead'. So, the term 'Mora Bharalu' refers to a dead rivulet in the form of 'Dead Bharalu' where the rivulet barely exists today. It signifies that the death of a river is already observed by the dwellers of the city. Thus, as the largest city in the region, Guwahati (famously called the 'Gateway to North-East India') observes an unprecedented growth in the recent times leading to some destructive environmental consequences.

10.2.4.1 Land use around Mora Bharalu

The river Mora Bharalu passes through city centre carrying heavy amount of domestic wastewater and solid garbage. From the land use map it can be observed that on both the bank of the river dense residential area is situated. Nearby commercial, industrial settlements also discharge their wastewater to this river, hence degrading the actual characteristics of the river.

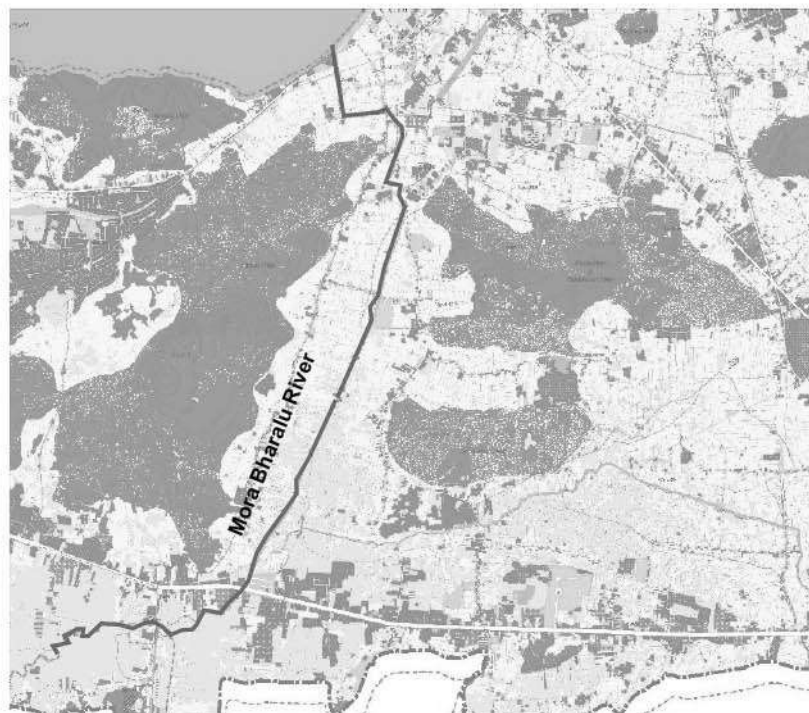


Figure 10-10: Landuse around Mora Bharalu River

10.2.4.2 Key Issues around Mora Bharalu River

The river Mora- Bharalu at Fatasil – Ambari stretch is highly polluted with solid waste and garbage. According to report published my GPlus media, residents of KK Road have complained about the polluted river and the foul smell it brings into their front yard. There is absence of dustbins in the locality and ineffective waste collection practice. During monsoon toxic black water enters the houses located along the river and damages the bridges and the makeshift road every time it rains 2-3 days. Flood water reaches the level the bridges over it.



Figure 10-11: Condition of River Mora Bharalu

10.3 Wetlands in Guwahati

Wetlands are the part where water is the primary factors controlling the environment and the associated plant and animal life of it. Under the Ramsar Convention's broad definition, wetlands are "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters". Wetlands are among the world's most productive environments. They are cradles and the backbone of biological diversity, providing the water and productivity upon which countless species of plants and animals depend for survival.

In Assam, there are 690 lakes and ponds as recorded. These lakes /ponds cover an area of 15494.00 ha which constitutes 0.20 percent of the total geographical area of the state and 15.30 percent of the total area under wetlands. The smallest of them measures 2.50 ha while the largest one has 882.50 ha of areal coverage. District- wise 3513 numbers of wetlands are identified in Assam-by-Assam Remote Sensing Application Centre, Assam.

10.3.1 Why to Conserve Wetlands?

Wetlands are often termed as 'nature's kidneys' or 'natural sink' due to its characteristics of cleansing the environment and balancing the water retention of the land. They are vital links between land and water that provides "ecosystem services" such as freshwater supply, habitat for many species, natural beauty, biodiversity, flood control reserve, groundwater recharge, climate change mitigation etc.

In the Guwahati City, the wetlands are basically found in the piedmont zone, low-lying areas, and intermountain valleys. Wetlands are also found along the course of the Brahmaputra River which receives its flood waters too.

10.3.2 Wetlands in Guwahati

The Guwahati city has numerous water bodies in the form of beels/wetlands, marshes, swamps, tanks and rivers. These water bodies not only have been integral aspect of the landscape, their eco system services have been critical in maintaining a healthy urban life. Several important wetlands including the Deepor Beel, the only Ramsar site in this part of the region along with the Silsako Beel, the Borsola Beel and the Sarusola Beel are spread around the city area.

Apart from these wetlands, numerous historic tanks/Phukhuris also exist within the city area which is another major aspect of the city biosphere. Each of these tanks viz. the Silpukhuri, Nakkatta Pukhuri, Jor Pukhuri and Dighali Phukhuri had their unique ecologies.

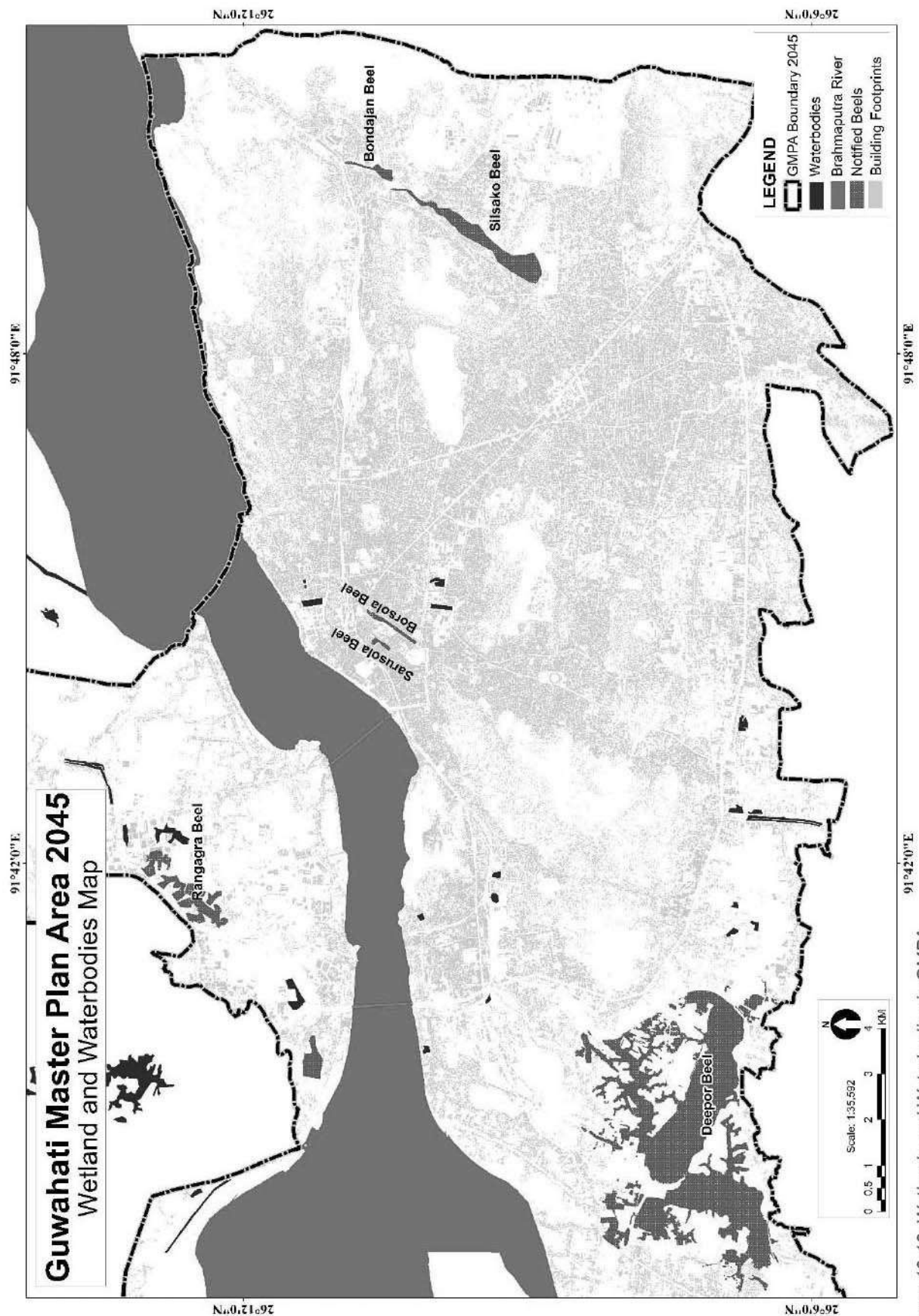


Figure 10-12: Wetlands and Waterbodies in GMPA



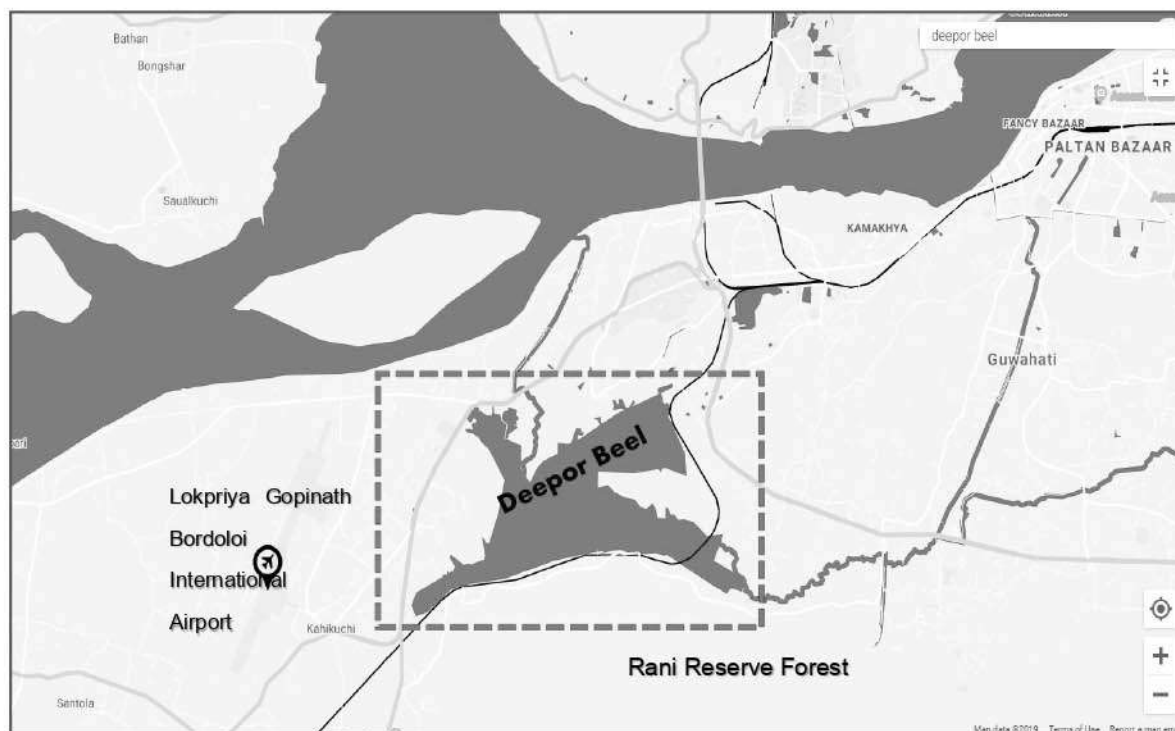
Figure 10-13: Notified Wetlands of Guwahati

10.3.3 Deepor Beel

Deepor Beel is a permanent freshwater lake and largest Beel in the Brahmaputra valley of Lower Assam. Deepor Beel is the only Ramsar site in Assam and amongst the third Ramsar site of the north-eastern region of India. It is located between latitude $26^{\circ}03'26''$ – $26^{\circ}09'26''$ N and longitude $90^{\circ}36'39''$ – $90^{\circ}41'25''$ E and situated 10 km southwest of Guwahati city, surrounded by residential, commercial and institutional areas. It is situated at an altitude of 53 meters above MSL, maximum depth is 4m, however during the dry season it drops to about 1 m. Ramsar Convention in 2002 declared 40.14 sq. km as Deepor Beel wetland and 4.14 sq. km area was proposed as a bird sanctuary under the Wildlife Protection Act of India, 1972 (Government of Assam, 1989). The main inlets of the beel are the Mora Bharalu and the Basishta-Bahini rivers which carry the sewage as well as rain water from Guwahati city. The only outlet of the beel is Khanajan located towards the northeast having connection with the main river Brahmaputra. The beel is fringed by Rani-Garbhangra reserve forest in the south and the beel has also been playing crucial role in catering the biological need of elephant population of Rani and Garbhanga Reserve Forest with other

important mammals of the area. The Deepor Beel and its fringe areas are made up of recent alluvium consisting of clay, silt, sand, and pebbles.

Figure 10-14: Location of Deepor Beel



Conservation History of Deepor Beel

- **1989** – Preliminary notification of Deepor Beel Wildlife Sanctuary. (Area: 4.1 sq.km).
- **1997**: Formation of Deepor Beel Management Act.
- **2002**: Declaration as Ramsar Site (Area: 40 sq.km)
- **2004**: Declaration of Important Bird Area (IBA) by Birdlife International.
- **2009**: Final Notification of Deepor Beel Wildlife Sanctuary (Area: 4.1 sq.km)

10.3.3.1 Hydrological Linkages of the Beel

The wetland receives most of its water content which from the River Basistha and the River Kalmoni during the monsoons. It then flows down to the Brahmaputra through the Khanajan stream, making Brahmaputra the natural storm runoff area for the city of Guwahati. The Remote Sensing study of Deepor Beel reports that the existing area of the wetland has been compressed to around 405 hectares, i.e., 14% in the last decade. An area of 414 hectares has been designated as the Bird Sanctuary but most of the area has been encroached by illegal settlements.

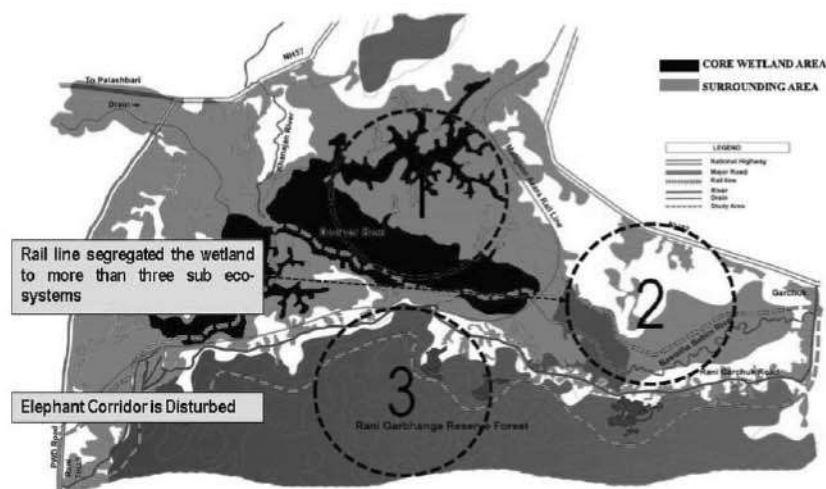


Figure 10-15: Hydrological linkages of the Beel

(Source: Transformation of Urban Wetlands as An Effect of Urban Development: An Analysis of Deepor Beel in Guwahati, Assam by SILPIREKHA PANDIT.)

10.3.3.2 Origin and Transformation of Wetland due to Urban Development

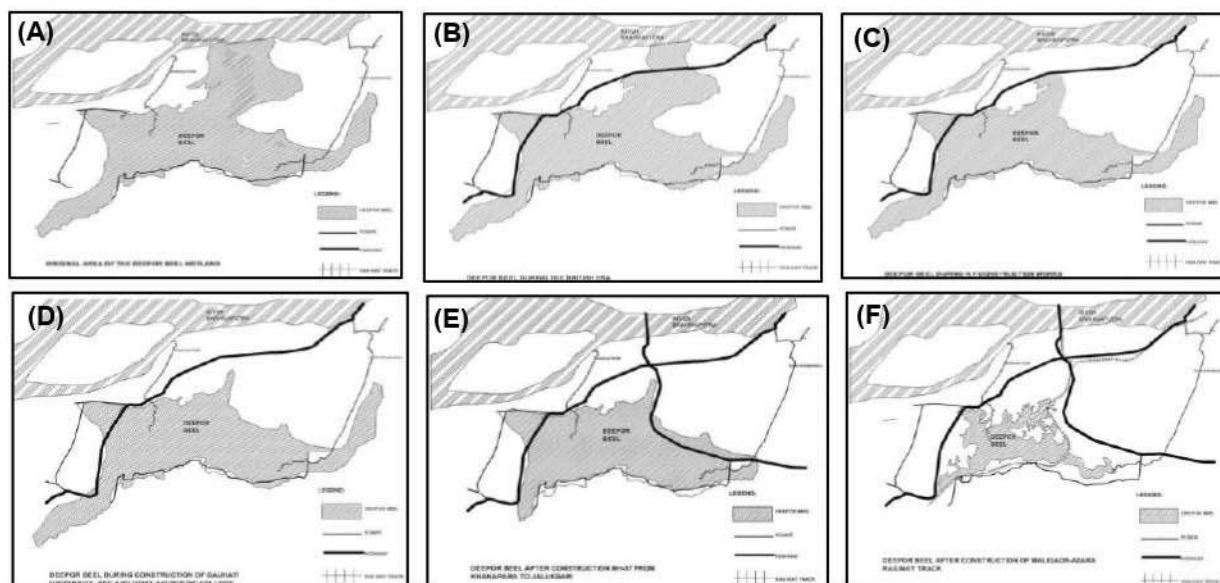


Figure 10-16: Origin and Transformation of Wetland due to Urban Development

(Source: Transformation of Urban Wetlands as An Effect of Urban Development: An Analysis of Deepor Beel in Guwahati, Assam by Silpirekha Pandit.)

The above figure shows the chronological transformation of Deepor Beel due to Urban Development picture A shows the original area of Deepor Beel, B shows its area during British era, C shows during N.F. construction works, D - Deepor Beel during construction of the University, AEC & Ayurvedic College, E - Transformation of the Deepor Beel and shrinkage of the wetland area – after construction of NH-37 from

Khanapara to Jalukbari. F- Transformation of the Deepor Beel and shrinkage of the wetland area – after construction of Maligaon – Azra railway track.

With urban development at its forefront, the waterbody and the biodiversity of Deepor Beel failed under threat, construction of the National Highway-37 and, other urban infrastructure projects in the surroundings, this link has been shallowed down and, even cut off in some parts of the wetland. The major blunder in the development process of the city, which affected the wetland the most, is the construction of the Northeast Frontier Railway track undertaken in 2001 across the Deepor Beel which divided wetland in two parts, which further led to the drying up of one part of the Beel the part dried up, settlements gradually started to develop in the area.

The recent establishment of the city's garbage centre at the heart of the eastern boundary at the Boragaon area has also contributed to heavy pollution of the waters of the Deepor Beel and, consequently, the spread of water-born contagious diseases and disease vectors.

10.3.3.3 *Polluted Water Body Stretch*

The total area of the polluted stretch of Deepor Beel is 40.14 sq. km. The area has been suffering from environmental degradation due to continuous encroachment and waste dumping as the Guwahati Municipality dump yard (24 Ha) located in Boragaon, lies in the eastern corner of Deepor Beel. The encroachment of the beel is also very evident and rampant as there are a number of dwelling units and cement structures and hence encroachment and settlements around the periphery has contributed to shrinking of the beel. The wetland ecosystem is also disturbed by the railway railroad in the southern boundary and the embankment for the railroad has resulted in the water flow blockage.

10.3.3.4 *Identification of Major Locality around Deepor Beel*

Guwahati is the only city located around 10 kms away from Deepor beel. However, the villages around Deepor Beel have a total population of approximately 5000 population and 1200 numbers of households most of which belong to lower income groups living under the poverty line and depend directly or indirectly on the wetland's natural resources. The major villages identified across the catchment areas are Chakardeo, Pamohi, Sakardhum Mikir, MatiaPahar, Deochotal, Maghuwapara, Banghara than, Dharapur Chariali, Gorchuk, Boragaonetc. These villages discharge

sewage of approximately 540 KLD which is very minimal and can be managed by adopting stringent remedial actions.

10.3.3.5 Quantity of sewage generated and existing sewage treatment capacities

Guwahati is the major city responsible for discharging of sewage, as the Deepor Beel serves as the storm water reservoir and usually filled up with rainwater generally by the end of June along with the city sewage through the Mora Bharalu rivulet. An estimated 540 KLD of sewage is generated from the catchment area of Deepor Beel.

10.3.3.6 Identification of towns for installing sewerage system and sewage treatment plants

Deepor beel is the only major storm water storage basin and acts as the natural storm water reservoir for the Guwahati city through the Mora Bharalu rivulet. Mora Bharalu river is a channel that is abandoned by the river Bharalu at Fatasil Ambari and meets Basistha Bahini river at Pamohi which eventually confluence with Deepor Beel. The length of the Mora Bharalu rivulet from Fatasil Ambari till the confluence with Deepor Beel is 13.5 kms and runs through Fatasil Ambari, Bishnupur, Kalapahar colony, Dhirenpara, Manpara, Subhash Pally, Garchuk and Pamohi. Hence the untreated Guwahati city sewage received by the wetland through the Mora Bharalu channel plays a major role in polluting the wetland. Sewage Treatment Plant has already been proposed for Guwahati city along the bank of River Bharalu at three points having total capacity of 75 MLD namely at Jonali point, another near the confluence of Borsola with Bharalu River at Sarabbhati area and the last one at just before confluence with Brahmaputra River at Bharalumukh. In this regard, Action Plan for Bharalu river has already been prepared along with the treatment capacity and cost estimate of the three proposed STPs.

Table 10-13: Sewage generation and gaps in treatment

Area	Population	Water Consumption (KLD)	Sewage Generation (KLD)	No. of STPs proposed	Existing Treatment capacity (KLD)	Gaps in KLD
Deepor Beel	5000	675	540	Nil	Nil	540

(Source: Action plan for Deepor Beel, PCB, Assam, 2019)

10.3.3.7 Water Quality of Deepor Beel

The water quality of Deepor Beel being monitored at two locations, Deepor Beel near Dharapur Chariali and another location is near IASST, Boragaon.

Table 10-14: BOD value in mg/l of Deepor Beel for the year 2016-19

Deepor Beel near Dharapur Chariali								Deepor Beel near IASST, Boragaon							
Year	BOD	Year	BOD	Year	BOD	Year	BOD	Year	BOD	Year	BOD	Year	BOD	Year	BOD
Jan-16	2.7	Jan-17	3.0	Jan-18	3.6	Jan-19	2.7	Jan-16	4.2	Jan-17	2.8	Jan-18	4.4	Jan-19	2.6
Feb-16	0.8	Feb-17	6.9	Feb-18	3.6	Feb-19	4.1	Feb-16	2.0	Feb-17	2.8	Feb-18	6.0	Feb-19	4.6
Mar-16	1.8	Mar-17	3.4	Mar-18	4.6	Mar-19	4.8	Mar-16	3.6	Mar-17	3.3	Mar-18	4.0	Mar-19	4.2
Apr-16	2.0	Apr-17	4.2	Apr-18	5.6	Apr-19	4.8	Apr-16	3.0	Apr-17	2.4	Apr-18	4.6	Apr-19	4.6
May-16	2.9	May-17	3.3	May-18	4.8	May-19	4.4	May-16	11.4	May-17	3.1	May-18	5.5	May-19	4.2
Jun-16	3.3	Jun-17	6.5	Jun-18	5.3	Jun-19	3.9	Jun-16	5.4	Jun-17	7.2	Jun-18	4.8	Jun-19	3.8
Jul-16	2.2	Jul-17	2.6	Jul-18	5.0	Jul-19	3.5	Jul-16	6.0	Jul-17	2.9	Jul-18	8.5	Jul-19	3.5
Aug-16	2.6	Aug-17	2.9	Aug-18	7.0	Aug-19	3.4	Aug-16	7.5	Aug-17	2.9	Aug-18	8.2	Aug-19	3.2
Sep-16	10.6	Sep-17	3.8	Sep-18	5.0	Sep-19	3.0	Sep-16	5.4	Sep-17	3.6	Sep-18	4.8	Sep-19	3.1
Oct-16	5.3	Oct-17	2.9	Oct-18	4.7	Oct-19	3.3	Oct-16	5.0	Oct-17	3.1	Oct-18	2.6	Oct-19	3.1
Nov-16	3.5	Nov-17	4.8	Nov-18	11	Nov-19	3.4	Nov-16	3.8	Nov-17	4.6	Nov-18	12.0	Nov-19	3.2
Dec-16	3.4	Dec-17	5.4	Dec-18	3.6	Dec-19	3.4	Dec-16	2.2	Dec-17	4.8	Dec-18	3.6	Dec-19	3.6

(Source: Action plan for Deepor Beel, PCB, Assam, 2019)

The above data indicated that the BOD value has failed to meet the standard criteria in most of the occasions. The BOD value which indicates organic load generally increases due to the waste generated from the activity of the residents in the form of domestic household waste through different drains and channels. This consistent exceedance of BOD value may be due to the untreated city sewage received by the wetland through the Mora Bharalu rivulet at confluence with Deepor Beel at Pamohi. The dumping of municipal solid wastes in its close proximity at Boragaon by the Guwahati Municipal Corporation (GMC) has also pushed the wetland's pollution to alarming levels. The problem gets aggravated during the monsoons, with rainwater sweeping large amounts of garbage from the dumping site to the Beel. Hence this constant failure to meet the standard criteria may be due to solid waste dumping site at Boragaon and the untreated city sewage as the Guwahati city does not have a Sewage Treatment facility for the waste. However, Action Plan for Bharalu river has already been prepared and approved by CPCB along with the treatment capacity and cost estimate of the three proposed STPs.

10.3.3.8 Drains contributing to pollution

No drains were observed to be directly connected to the beel. However, Deepor beel is the only major storm water storage basin and acts as the natural storm water reservoir for the Guwahati city through the Morabharalu rivulet. Morabharalu river is

an abandoned channel by the river Bharalu at Fatasil Ambari and meets Basistha-Bahini river at Pamohi and eventually confluence with Deepor Beel. The length of the MoraBharalu rivulet from Fatasil Ambari is 13.5 kms and runs through Fatasil Ambari, Bishnupur, Kalapahar colony, Dhirenpara, Manpara, Subhash Pally, Garchuk and Pamohi.

10.3.3.9 Characteristics of Major Drains

The Mora Bharalu rivulet which joins the Basistha Bahini River mainly carries sewages. The water quality of the Mora Bharalu rivulet is presented in Table 10-15.

Table 10-15: Analysis of Surface water quality of Mora Bharalu connecting to Deepor Beel

SI No.	Parameter	Value
1	D.O. (mg/L)	4.5
2	pH	7.4
3	BOD (mg/L)	4.8
4	COD (mg/L)	28.3
5	RCI2 (mg/L)	0.4
6	TSS (mg/L)	44.0
7	TDS (mg/L)	106.0
8	Free NH ₃ -N (mg/L)	Nil
9	Total Chromium (mg/L)	BDL
10	Nickel (mg/L)	BDL
11	Cadmium (mg/L)	BDL
12	Zinc (mg/L)	0.026
13	Mercury (mg/L)	BDL
14	Total Coliform (MPN/100ml)	15000
15	Faecal Coliform (MPN/100ml)	2000

(Source: Action plan for Deepor Beel, PCB, Assam, 2019)

10.3.3.10 Drainage system/ sewerage network present/proposed

Encroachment has blocked the natural drainage pattern of the Deepor Beel causing the water level imbalance in the Beel. Natural drainage of local origin like Basistha Bahini, Mora Bharalu and kalmani are responsible for draining off majority of the city sewage. There is no sewerage system at present. Three numbers of STPs along with interceptor drains for collection of the sewage of the basin has been proposed at Guwahati city. All the sewage of the catchment area of the river/wetland shall be collected by interceptor drains and shall be treated in the proposed STPs before outfall into the river/wetland.

10.3.3.11 Controlled Ground Water Extraction and quality Assessment

About 49% of the households rely on tube well to obtain potable water. Very few numbers of the population owns earthen well whereas some of them depends on both supplied water as well as concrete well.

The details of estimated ground water resource in Kamrup district is presented below

Table 10-16: Estimation of ground water resource in the Kamrup district

Ground Water Extraction Details	Ground Water
Gross Ground Water Draft	1487.29 mcm
Net Ground Water Availability	715.97 mcm
Stage of Ground Water Development	43%
Existing Draft for Irrigation Use	586 mcm
Future Provision for Domestic & Industrial Use	105.16 mcm

(Source: Action plan for Deepor Beel, PCB, Assam, 2019)

Apart from dependency on ground water rainwater harvesting is also being practiced in area. For irrigation practices minor and medium irrigation schemes such as DTW and STW are provided and for recharging of ground water ponds and lakes are created under various government schemes. Thus, it can be stated that Kamrup district is still under 'Safe' category and sufficient resources are still available for future development.

10.3.3.12 Status of Ground water

The water quality is found to be well within the permissible limit for drinking, irrigation and industrial purposes. Due to slightly higher content of iron in some sporadic patches of the area and fluoride content exceeding permissible limit in some pockets in and around Guwahati City, water needs to be treated before being used for drinking purpose. However, as per the data generated from PCBA, the ground water quality around the Deepor Beel areas is found to be within the permissible limit and safe for domestic and irrigation purposes.

10.3.3.13 Flood Plain Zone near Deepor Beel

In the surroundings of Deepor Beel few locations are identified as vulnerable to seasonal floods and notified by the administration and these areas are Chakardeo, Pamohi, Sakardhum Mikir, MatiaPahar, Deochotal, Maghuwapara, Banghara Than.

10.3.3.14 Key Issues near Deepor Beel

Around 2km buffer of Deepor Beel covers an area 64.68 sq. km, the water spread areas, forest cover, fallow and barren lands, built up area from 1977 to 2014 show

significant changes illustrated in the following Figure 10-17. In spite of attaining Ramsar site status by the Deepor Beel and also efforts made by the concerned authorities to save the wetlands, more encroachment and faster degradation of the wetland environment observed being it located in urban area. Wetland proper reduced in Deepor Beel occurred mainly due to encroachment which has been partly compensated by de-siltation⁵

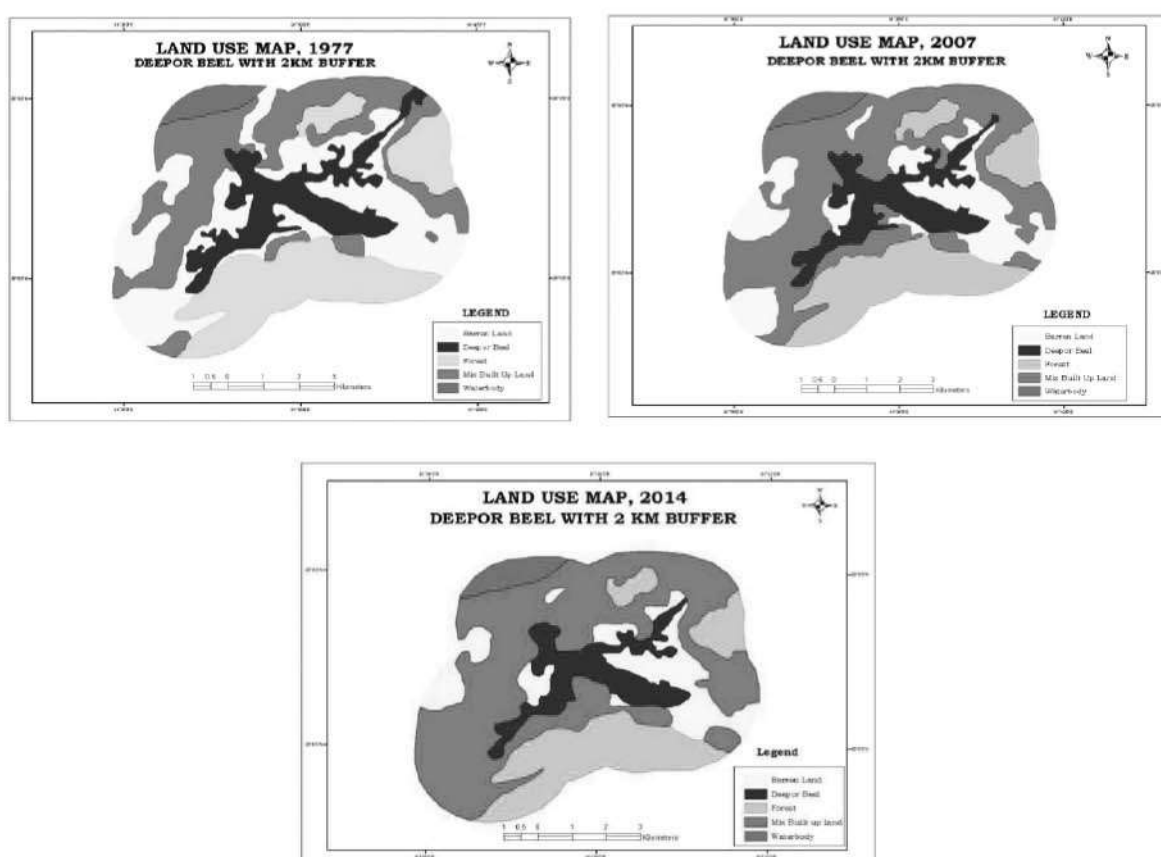


Figure 10-17: Land Use of 2 km Buffer Area of Deepor Beel, 1977 (Top, left); Land Use of 2 km Buffer Area of Deepor Beel, 2007 (Top, right); Land Use of 2 km Buffer Area of Deepor Beel, 2014 (Down)

Impact on Deepor Beel Environment:

Rapid growth of city population and land cost increase has resulted in the encroachment of the Deepor Beel. Northern and eastern parts of the Beel have been occupied by the private as well as the government organizations.

Encroachment has blocked the natural drainage pattern of the Deepor Beel causing the water level imbalance in the Beel. Soil erosion and improper catchment treatment and agricultural practices have led to sedimentation in the Beel.

⁵ Land use change in the peripheries of wetlands and its impact on the Water bodies: A comparative study in the Deepor and Urapad beels of Assam, India

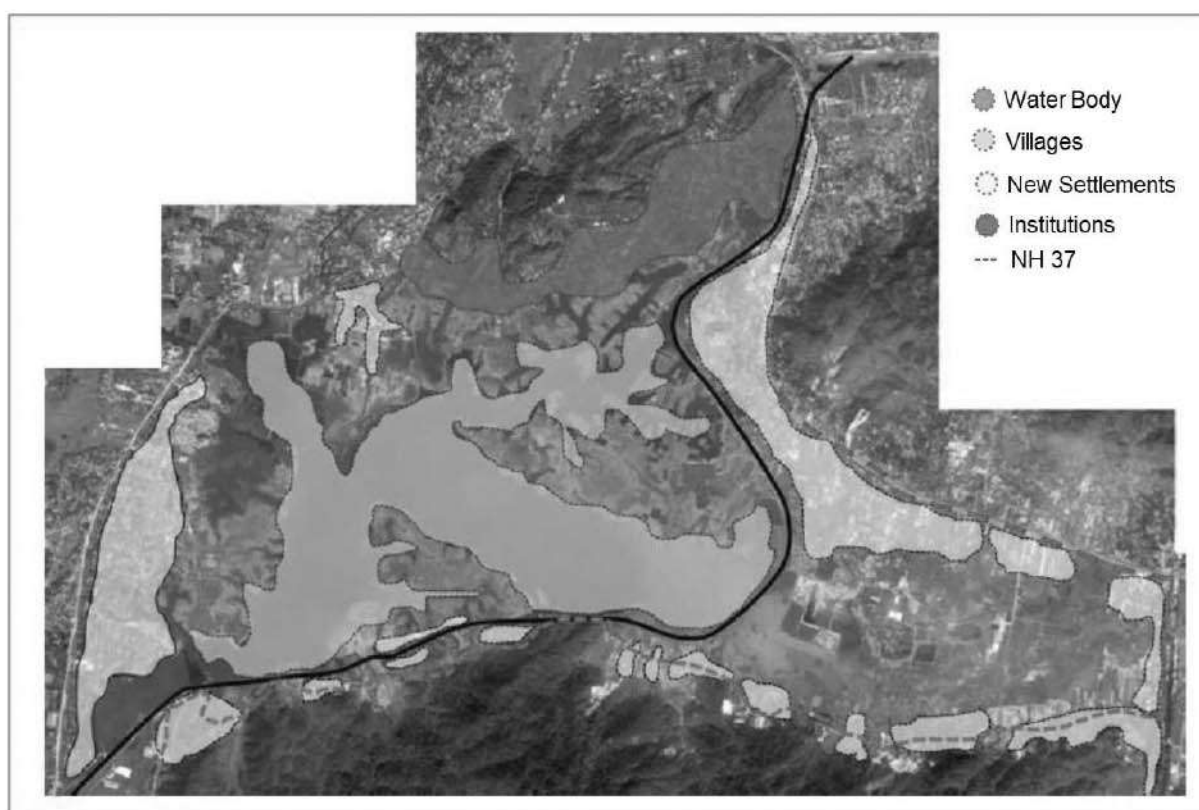


Figure 10-18: Map Showing settlements near Deepor Beel³

The growth of aquatic weeds has been observed in the Deepor Beel area. Major cause of weeds growth is mainly because of the nutrients and sewage flow to the Beel. Chemical manure in the agricultural land in the nearby areas of supply to the Beel⁶.

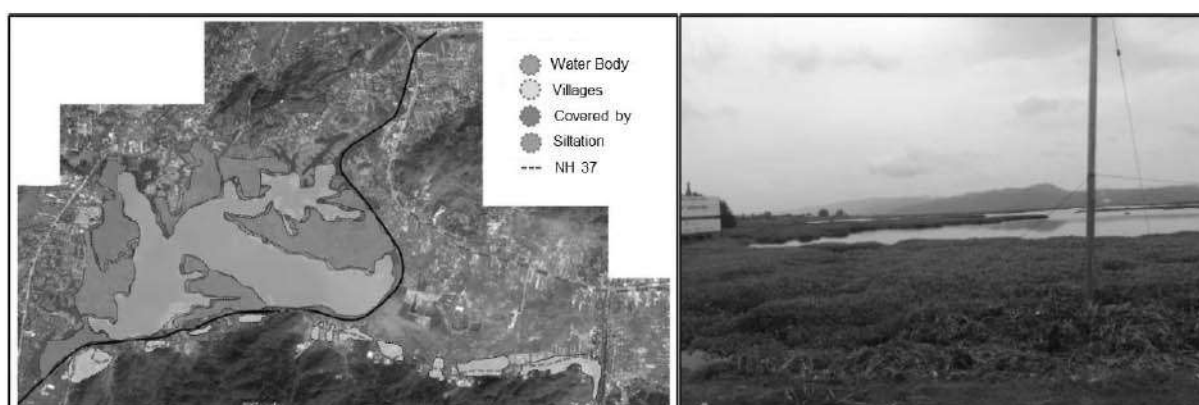


Figure 10-19: Map showing areas of siltation and weeds³

Guwahati Oil Refinery waste is directed through the Bharalu and Kalmoni rivers to the Beel. The channels also carry other industrial and hospital waste to the Beel. The

⁶ Koushik Praschaya, 2012, Need for eco sensitive planning a case of Guwahati, CEPT University library

water has turned black and smelly. Sewage discharge into the water might have caused the fall in oxygen levels resulting in the death of fishes.



Figure 10-20: Map showing Guwahati Refinery

Waste Dumping near Deepor Beel

Dumping of municipal solid wastes in its close proximity at Boragaon by the GMC has pushed the wetland's pollution to alarming levels. The problem has got aggravated during the monsoons, with rainwater sweeping large amounts of garbage from the dumping site to the Beel which now results the death of carp fishes – Rohu, Mrigal, Katla, etc. at the Deepor Beel was the maximum as compared to other species.

There are lots of stone quarries existed in the Rani hill. During rainy season the mud water coming from the hills and settled under the bill which causes siltation and results in the decreasing the depth of the Beel.



Figure 10-21: Satellite imagery showing Deepor Beel Catchment area and the Dumping Sites managed by GMC

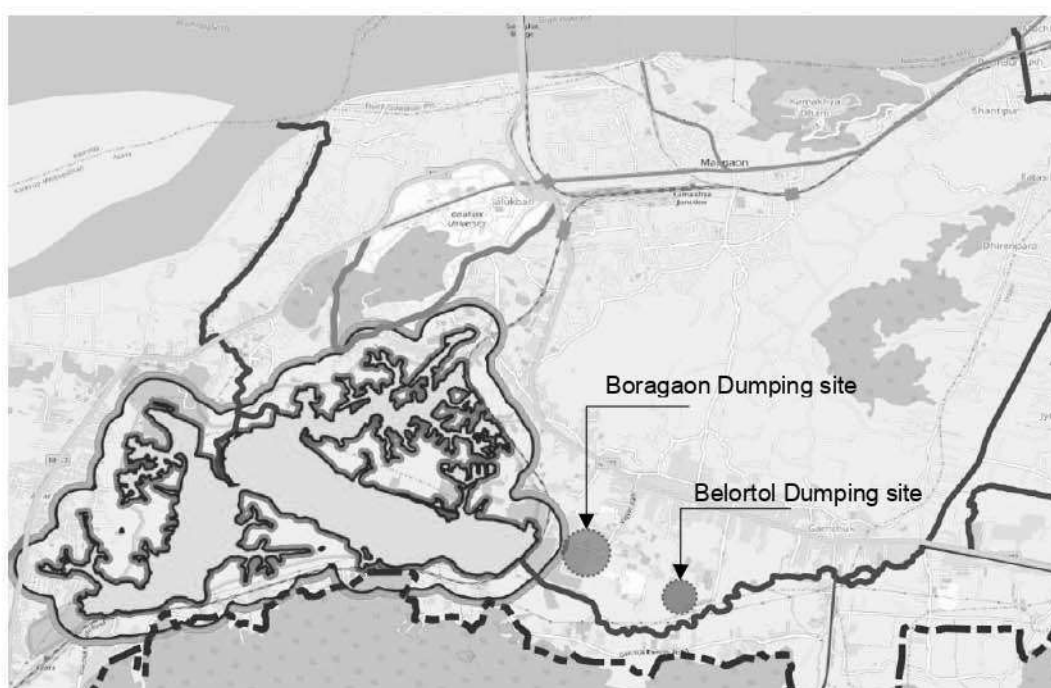


Figure 10-22: Map Showing Waste Disposal areas in Guwahati and its connectivity with the nearby waterbodies

Industrial activities near Deepor Beel:

Establishment of industries within periphery of the wetland system is leading to water quality deterioration and soil pollution. Permitting temporary brick kilns and associated soil quarrying from within the wetland have led to massive destruction of top soil and other ecosystem components⁷.

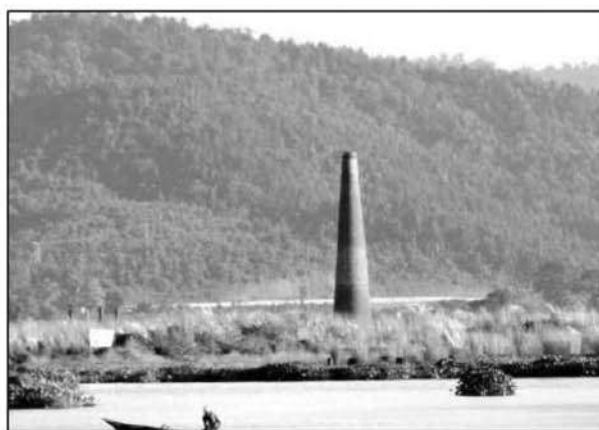
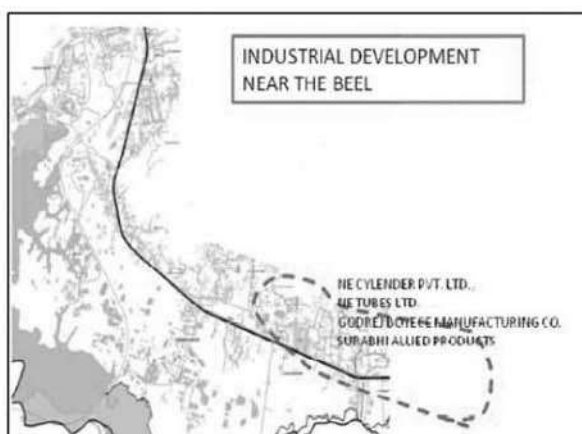


Figure 10-24: Map showing Industry areas near Deepor Beel. Figure 10-23: Brick Kiln near Deepor Beel

⁷ Koushik Praschaya, 2012, Need for eco sensitive planning a case of Guwahati, CEPT University library

Hunting, trapping and killing of wild birds and mammals and community fishing activities has adversely affected the Beel ecosystem. Community fishing and catching of gravid and brood fishes are causing sharp decline of fish productivity of the wetland. Species diversity and species habitat has been changed due to the unplanned fishing practice performed by the village people near the fringe areas of the Deepor Beel⁸.



Figure 10-25: Fishing Activity in Deepor Beel

10.3.4 Borsola Beel

Borsola Beel is in the centre of the city near Paltan bazar area. The Beel site is located in middle of the Guwahati City approx. 750 m southwest of the Guwahati Railway station by the Road. The co-ordinates (in Latitude and Longitude) of the site are 26°10'22.9"N, 91°44'45.8"E. Borsola Beel is connected with number of drains at



Figure 10-26: View of Borsola Beel

⁸ Koushik Praschaya, 2012, Need for eco sensitive planning a case of Guwahati, CEPT University library

various locations through secondary and tertiary drain, though majority of discharge received through the culvert near Nepali Mandir. It is formed by receiving the overflow and inundated waters of the River Bharalu in its low-lying area. In course of time, the low-lying areas have been shrunk and dried out due to changes in its way and for the new land use pattern of the city. The present Borsola is the remains of the larger low-lying area of the River Bharalu. It is well connected with small inlets and feeder channels.

The Borsola is developed along a small drainage network and it is surrounded by the residential areas of Rehabari, Nepali Mandir, Paltanbazar, Chatribari and Chabipool.

The present extent of the Borsola wetland is from the culvert at Nepali Mandir-Rehabari Road in the north, Beelpar residential area in its eastern periphery, Chatribari residential area in the western periphery and the Chabipool (low-lying area) commercial area in the southern corner. Originally, the Borsola wetland had the characteristics of marshy land, because this wetland was formed in the low-lying areas along the banks of River Bharalu.

As it was adjacent to the River Bharalu, it used to have a clear water body throughout the year. But due to its central location inside the city, this wetland has lost its natural characteristics of a marshy land. Due to rapid development activities, the drainage system has been dried up and the surface waterbody has become stagnant. At present, this wetland merely looks like a small tank or pond.

10.3.4.1 *Significance of Borsola Beel*

The presence of the Borsola wetland in the low-lying area of River Bharalu and its central location inside the Guwahati city has also been very significant in the overall environment of the core part of the city. The possible functions performed by Borsola are as follows:

1. Being in the center of the city, it acts like a 'storm water basin'. It receives flash flood water and excess precipitation water through its one major and three minor inlets and feeder channels.
2. It helps in the groundwater purification process of the area through inflow outflow, infiltration, and ground water recharge.
3. In a so-called concrete jungle of city, it helps to keep the local weather cool in its surroundings, and it provides fresh oxygen to the air

Existing Sewage Treatment Plant (STP) of 1.5 MLD capacities is located at the upstream side of the Beel near Assam Paryatan Bhawan. The STP is in defunct

condition. Starting stretch of the Beel near the existing STP along East and West both the banks of the Beel are highly populated. The existing walkway (1460 m) on either banks projecting into the Beel. Borsola Beel is full of silt, solid waste and garbage. Lot of vegetation and trees has grown up in the Beel. At the end of the Beel a lock gate is located. The gate is placed to control the back flow and out flow of the Beel.

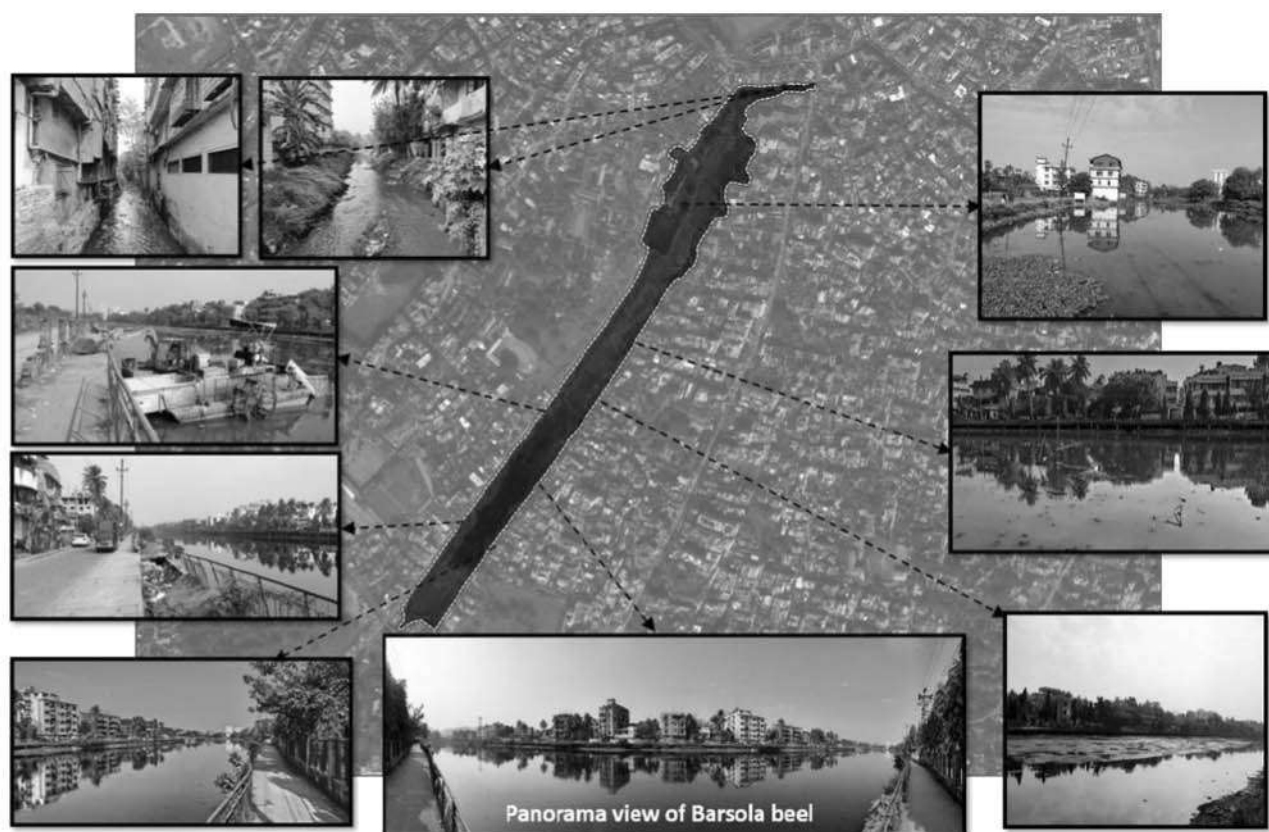


Figure 10-27: View of Borsola Beel

10.3.4.2 Inlets and Outlets of Borsola Beel

The Borsola wetland runs in an elongated shape from NE (North-East) to SW (South-West) direction along a network of streams (inlets and outlet, locally known as nala). The inlets act as feeder channels of Borsola, discharge lots of water and other waste materials from different sources of the catchment area of the wetland. It feeds by one major and three minor inlet feeder channels, which are the only source of water of Borsola apart from the atmospheric precipitation.

The major inlet is the Paltanbazar inlet, which originates in the hillocks of Chandmari area, flows through Chandmari-Silpukhuri-Gandhi basti Solapara-Manipuri basti-Paltanbazar area and meets Borsola at culvert located at Nepali Mandir-Rehabari Road.

In the eastern periphery, there are two inlets, viz.

- (i) Beelpar inlet flows through Beelpar area and meets the wetland in the middle part of eastern periphery of Borsola and
- (ii) Rehabari inlet flows through Rehabari area and meets the wetland in north-eastern corner of Borsola.

In the western periphery, there is only one inlet:

- (i) Chatribari inlet, flows through AT Road-Takoubari-Chatribari area and meets Borsola in the middle part of western periphery.

The discharge outlet of Borsola has a switch gate in the southern end. After crossing the switch gate, the discharge outlet of Borsola meets Bharalu River in the south-eastern point.

10.3.4.3 Polluted Water Body Stretch

The Beel is having a length of 1.5 km and average width of 50 m which is presented below.



Figure 10-28: Polluted Borsola Wetland (source: Action plan for Borsola Beel, PCB, Assam)

10.3.4.4 Identification of Major Locality around Borsola Beel

The Beel runs through the heart of the Guwahati city surrounded by places like Chatribari, Rehabari, Paltan Bazar on the Upstream of the Project. Total population residing on either side of the Beel is approximately 1,22,000 and water consumptions stands at around 16.5 MLD. The details of sewage generation and the gap in treatment is presented below

Table 10-17: Sewage generation and gaps in treatment at present

Area	Population (Census 2011)	Water Consumption (KLD) @135 lpcd	Sewage Generation (KLD)	No. of STPs proposed	Existing Treatment capacity (KLD)	Gaps in KLD
Borsola Beel	122000	16470	13176	01	Nil	13176

(Source: Action plan for Borsola Beel, PCB, Assam, 2019)

10.3.4.5 Drains Contributing to Pollution

Chandmari Drain, Rehabari Drain and connecting combined sewage drains from surrounding areas outfalls into the Beel. Approximate 10 numbers of inlets are connected to the Beel. Out of these, there are some major inlets.

10.3.4.6 water quality and current as per assessment targeted

The water quality test has been carried out at Borsola Beel at one locations since July 2017 under NWMP. The sample is tested for various parameters and the Summary of water quality parameters for the month of April, 2019 are as follows

Table 10-18: Analysis report of Borsola Beel near Sarabbhati- April 2019

Sl. No.	Parameter	Value
1	pH	6.8
2	Cond (μ S/cm)	354
3	BOD (mg/L)	20.1
5	COD (mg/L)	51.7
6	NO ₃ - N (mg/L)	2.7
7	TSS (mg/L)	108
8	Turbidity (NTU)	18
9	p-Alkalinity (mg/L)	Nil
10	m-Alkalinity (mg/L)	182
11	Hardness (mg/L)	108
12	Calcium as CaCO ₃ (mg/L)	76
13	Magnesium as CaCO ₃ (mg/L)	32
14	Chloride as Cl (mg/L)	36
15	Total Iron (mg/L)	0.14
16	Copper (mg/L)	BDL
17	Arsenic(mg/L)	BDL

(Source: Action plan for Borsola Beel, PCB, Assam, 2019)

10.3.4.7 Characteristics of the river and the major drains

Several Municipal Drains are connected to the Borsola Beel, carrying sewage/ waste/storm water and discharges directly into the Borsola Beel. Major contributor of wastewater flow is through the drain at the upstream end of Beel at Nepali Mandir. Borsola Beel receives wastewater through several inlets. Approximate 10 numbers of inlets are connected to the Beel. Out of these, there are some major inlets.

The water body has been receiving heavy loads of silt, sewage and solid waste and the water quality has deteriorated beyond limits. Luxuriant growth of water hyacinths, weeds are visible in the water spread area of the Beel. The quality of the water is very poor. Heavy deposit of silt/sludge has been accumulated on the bed of the Beel for years.

The details of water quality of major drains contributing to pollution in the wetland are presented below:

Table 10-19: Analysis report of the major drains contributing to pollution in the Borsola Beel

Sl. No.	Parameter	Drain 1 (Chandmari Drain)	Drain 2 (Rehabari drain)
1	D.O. (mg/L)	Nil	Nil
2	pH	7.4	7.4
3	Cond (µS/cm)	419	426
4	BOD (mg/L)	44.0	48.0
5	COD (mg/L)	122	128
6	NO ₃ - N (mg/L)	1.3	1.6
7	TSS (mg/L)	122	128
8	Turbidity (NTU)	07	10
9	p-Alkalinity (mg/L)	Nil	Nil
10	m-Alkalinity (mg/L)	210.0	198.0
11	Hardness (mg/L)	142.0	148.0
12	Calcium as CaCO ₃ (mg/L)	94.0	106.0
13	Magnesium as CaCO ₃ (mg/L)	48.0	42.0
14	Chloride as Cl (mg/L)	42.0	38.0
15	Total Iron (mg/L)	0.56	0.68
16	Copper (mg/L)	0.002	0.004
17	Arsenic(mg/L)	BDL	BDL
18	Faecal Coliform (MPN/100ml)	2300	4300

(Source: Action plan for Borsola Beel, PCB, Assam, 2019)

10.3.4.8 Flow details of the polluted river stretch

Discharge has been measured at the inlet at culvert location and outlet at lock gate of the Beel and it is around 0.60 m³/sec and 0.45 m³/sec respectively. All the drains which are falling to Beel carries storm water and domestic sewage.

10.3.4.9 Ground water quality in the polluted river stretch

The water quality is found to be well within the permissible limit for drinking, irrigation and industrial purposes. Due to slightly higher content of iron in some sporadic patches of the area and fluoride content exceeding permissible limit in some pockets in and around Guwahati City, water needs to be treated before being used for drinking purpose.

Table 10-20: Ground water Quality of Shantipur area (catchment of Borsola Beel) under NWMP

Sl. No.	Parameter	Value
1	pH	6.8
2	Cond ($\mu\text{S/cm}$)	193
3	BOD (mg/L)	2.7
5	COD (mg/L)	5.4
6	NO ₃ - N (mg/L)	0.7
7	TSS (mg/L)	20
8	Turbidity (NTU)	6
9	p-Alkalinity (mg/L)	Nil
10	m-Alkalinity (mg/L)	84
11	Hardness (mg/L)	62
12	Calcium as CaCO ₃ (mg/L)	40
13	Magnesium as CaCO ₃ (mg/L)	22
14	Chloride as Cl (mg/L)	22
15	Total Iron (mg/L)	0.56
16	Copper (mg/L)	0.006
17	Arsenic(mg/L)	0.004

(Source: Action plan for Borsola Beel, PCB, Assam, 2019)

10.3.4.10 Flood Plain Zone near Borsola Beel

Chatribari, Rehabari and Sarabbhati are the notified areas prone to flash floods situated around the Beel.

10.3.5 Sarusola Beel

The Sarusola Beel lying in the central part of the city is again one of the highly degraded beels within the city. The Sarusola beel has the potential to serve Chandmari, Gandhibasti, Solapar, Ulubari, Manipuribasti, Fancybazar, Panbazar, Paltanbazar, Lakhtokia, Tokobari, AT Road (near the Police Reserve), Satribari and Athgaon areas as a storm water reservoir. The beel once provided a habitat for many flora and fauna and used to contain rainwater from nearest hills and plains. Of late, it has turned into a dumping ground for municipal and household wastes. Encroachment, heavy settlement within the fringe areas, discharge of storm water and sewage directly into the beel and subsequent eutrophication has choked and degraded the beel to a deplorable extent. The Beel is located at Athgaon area amidst of huge urban development in the Guwahati City approx. 2.5 Kms southwest of the Guwahati Railway station by the Road. The co-ordinates (Latitude and Longitude) of the site perimited are 26°10'31.1"N, 91°44'34.6"E. The Beel is having a length of 560 m and average width of 50 m. There is KC Das Commerce College at south side and surrounded by Chatribari road at east and north side. At the west side of the Beel Mahapurush Damodardev Path is passing by. The Beel is connected with number of

drains at various locations through secondary and tertiary drain, the majority of discharge received from south near KC Das Commerce College. Sarusola Beel is full of silt, solid waste and garbage. Lot of vegetation has grown up in the Beel.

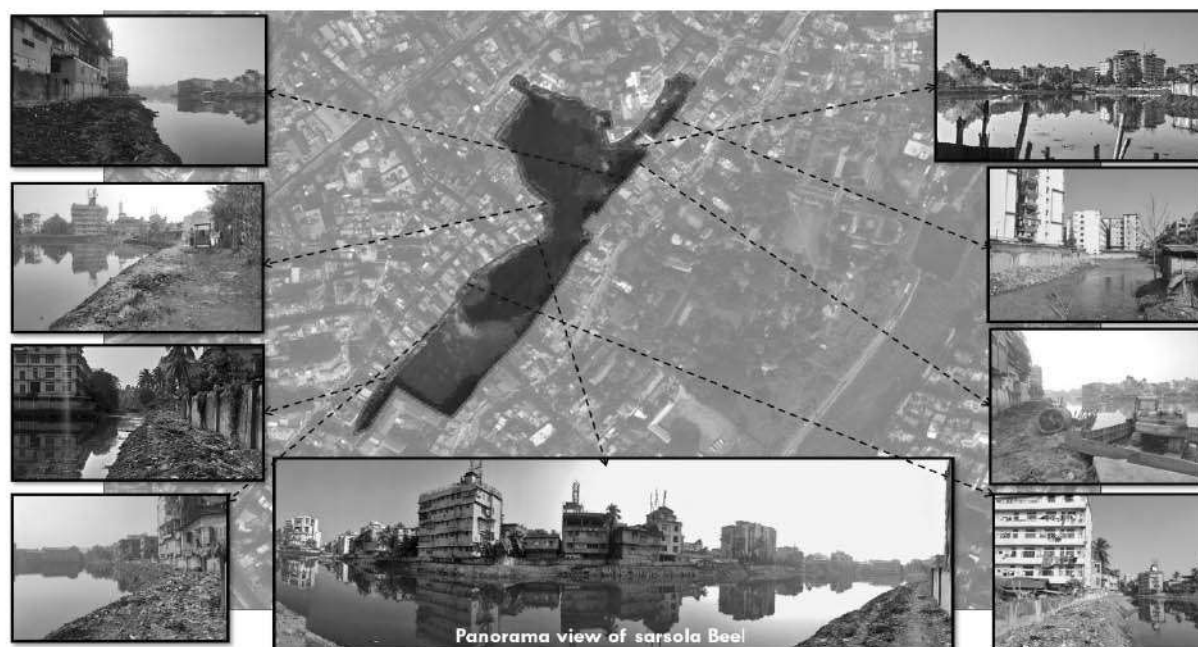


Figure 10-29: Views of Sarusola Beel

10.3.5.1 Major towns located on the bank between the stretches including population, water consumption details

Athgaon, Tokobari and Chatribari area are the locality identified surrounding the Beel area. Total population residing on either side of the Beel is approximately 80000 and water consumptions stands at around 10.8 MLD.

Table 10-21: Sewage generation and gaps in treatment

Area	Population (Census 2011)	Water Consumption (KLD) @135 lpcd	Sewage Generation (KLD)	No. of STPs proposed	Existing Treatment capacity (KLD)	Gaps in KLD
Sarusola Beel	80000	10800	8640	NIL	Nil	8640

(Source: Action plan for Borsola Beel, PCB, Assam, 2019)

No STPs have been proposed for this wetland. Installation of mechanical aerators is proposed, by using a combined system of low-energy compressors and diffusers would improve water quality of the lake and arrest degradation caused by sewage draining into the lake. The oxidation helps to reduce algae, weeds, remove organic bottom muck, improve fish growth and reduce foul odours.

10.3.5.2 *Drains Contributing to Pollution*

Drains coming from Athgaon, Chatribari, Tokabari and surrounding areas and connecting combined sewage drains from surrounding areas outfalls into the Beel.

10.3.5.3 *Latest water quality and current as per assessment targeted*

The water quality test has been carried out at Sorousal Beel at one location since July 2017 under NWMP. The sample is tested for various parameters and the summary of water quality parameters for the month of April, 2019 results are as follows

Table 10-22: Analysis report of Sarusola Beel near Sarabbhati- April 2019

SI No.	Parameter	Value
1	D.O. (mg/L)	Nil
2	pH	7.1
3	Cond (μ S/cm)	355
4	BOD (mg/L)	18.5
5	COD (mg/L)	55.2
6	NO ₃ - N (mg/L)	3.2
7	TSS (mg/L)	110
8	Turbidity (NTU)	13
9	p-Alkalinity (mg/L)	Nil
10	m-Alkalinity (mg/L)	186
11	Hardness (mg/L)	108
12	Calcium as CaCO ₃ (mg/L)	78
13	Magnesium as CaCO ₃ (mg/L)	30
14	Chloride as Cl (mg/L)	36
15	Total Iron (mg/L)	0.20
16	Copper (mg/L)	0.002
17	Arsenic(mg/L)	BDL
18	Faecal Coliform (MPN/100ml)	4300

(Source: Action plan for Borsola Beel, PCB, Assam, 2019)

10.3.5.4 *Characteristics of the river and the major drains*

Several Municipal Drains are connected to the Sorousla Beel, carrying sewage/ waste / storm water and discharges directly into the Sorousla Beel. Major contributor of wastewater flow is through the drain near KC Das Commerce College. Sorousla Beel receives wastewater through several inlets. The water body has been receiving heavy loads of silt, sewage and solid waste and the water quality has deteriorated beyond limits. The quality of the water is very poor. Heavy deposit of silt/sludge has been accumulated on the bed of the Beel for years. The details of water quality of the major drains contributing to pollution in the wetland are presented in the following table 10-23.

Table 10-23: Analysis report of the major drains contributing to pollution in the Sarusala Beel

Sl No.	Parameter	Drain near KC Das Commerce college	Drain from Chatribari area
1	D.O. (mg/L)	Nil	Nil
2	pH	7.4	7.3
3	Cond (μ S/cm)	418	392
4	BOD (mg/L)	42.0	40.0
5	COD (mg/L)	132	122.4
6	NO ₃ - N (mg/L)	1.4	1.8
7	TSS (mg/L)	124	132
8	Turbidity (NTU)	10	08
9	p-Alkalinity (mg/L)	Nil	Nil
10	m-Alkalinity (mg/L)	198.0	182.0
11	Hardness (mg/L)	146.0	130.0
12	Calcium as CaCO ₃ (mg/L)	112.0	86.0
13	Magnesium as CaCO ₃ (mg/L)	34.0	44.0
14	Chloride as Cl (mg/L)	48.0	42.0
15	Total Iron (mg/L)	0.56	0.58
16	Copper (mg/L)	0.002	0.002
17	Arsenic(mg/L)	BDL	BDL
18	Faecal Coliform (MPN/100ml)	9300	3900

(Source: Action plan for Borsola Beel, PCB, Assam, 2019)

Discharge has been measured at the inlet at KC Das Commerce College and it is around 0.35 m³/sec. The contributing major drains out falling in to the Beel carries domestic sewage.

10.3.5.5 Ground water quality in the polluted river stretch

The water quality is found to be well within the permissible limit for drinking, irrigation and industrial purposes. Due to slightly higher content of iron in some sporadic patches of the area and fluoride content exceeding permissible limit in some pockets in and around Guwahati City, water needs to be treated before being used for drinking purpose. The following table provides the details of ground water quality of Shantipur area (catchment of Sarusola Beel) under NWMP.

Table 10-24: Ground water Quality of Shantipur area (catchment of Sorusala Beel) under NWMP

Sl. No.	Parameter	Value
1	pH	6.8
2	Cond (μ S/cm)	193
3	BOD (mg/L)	2.7
5	COD (mg/L)	5.4
6	NO ₃ - N (mg/L)	0.7
7	TSS (mg/L)	20
8	Turbidity (NTU)	6
9	p-Alkalinity (mg/L)	Nil
10	m-Alkalinity (mg/L)	84

11	Hardness (mg/L)	62
12	Calcium as CaCO ₃ (mg/L)	40
13	Magnesium as CaCO ₃ (mg/L)	22
14	Chloride as Cl (mg/L)	22
15	Total Iron (mg/L)	0.56
16	Copper (mg/L)	0.006
17	Arsenic(mg/L)	0.004

(Source: Action plan for Borsola Beel, PCB, Assam, 2019)

10.3.5.6 Flood Plain Zone around Sarusola Beel

Chatribari, Rehabari and Sarabbhati are the notified areas prone to flash floods situated around the Beel.

10.3.6 Silsako Beel

Silsako Beel is spread over an area of 1000 Bighas of land as per the revenue records. The notified area of Silsako Beel as per the Guwahati Waterbodies (Preservation and Conservation) Act 2008 has been mapped in Geographical Information Systems (GIS) by GMDA and ASTEC. As a large wetland ecosystem and water body that is seasonally flooded with storm water runoff from the surrounding hilly terrain, Silsako Beel provides a natural setting with an emergent urban edge. The basin is located in the easternmost region of the Guwahati metropolitan district. The area occupied by the basin is approximately 2.8 sq.km. The wetland is bordered by Amchang wildlife sanctuary in the east, VIP road in the west, Narengi north and Chachal in west.

It is relatively a big wetland, originally comprises of four small wetlands in the eastern margin of Guwahati City, viz., Daulbari, Tepar, Silsako or Narengi and Damal beels, but at present the entire wetland complex is known as **Silsako beel**.

This wetland complex has developed along a small drainage network and it is surrounded by the Hills of Narengi in the north, Buragohain Hills in east and the Japarigog Hills in the west.

From these hills a number of inlets (feeder channels, locally called as nallas) and streams originate to feed the wetland. The constriction of Narengi Hills and Buragohain Hills at the north eastern end separates the Silsako wetland from those wetlands of the north, which are along the course of the Brahmaputra River and receive its floodwater during the monsoons.



Figure 10-30: Views of Silsako Beel



Figure 10-31 Silsako beel

10.3.6.1 Significance of Silsako beel

The presence of the Silsako wetland in the inter-mountain zone of Buragohain Hills and Japarigog Hills has a great significance in the overall environmental scenario of the city. The possible functions performed by Silsako are as follows:

1. Silsako is a natural wetland, which is one of the most important natural drainage to carry rainwater of Guwahati city.
2. It has its own isolated drainage system along with one major and six minor inlets feeder channels, which used to be the only source of water to the wetland.

3. It acts as 'Natural Storage Basin' by holding the excess water coming from the nearby hill areas, in this way it helps to control the effect of severe flash floods.
4. The wetland has great economic value, especially for the fishing community. The local people have been earning their livelihood by fishing and by selling aquatic vegetation as fodder for the animals. The collection of different types of fodder and selling them in nearby market areas is an important economic activity of the people of that area.
5. Ecologically it is of great significance for an area as they support different food chains and food web, recharge ground water and trap solar energy and provide shelter to large number of flora and fauna having great ecological and economical value.

The report was submitted to GDD, DC (Kamrup (Metro)) in July 2015. As per the report, there is no existing physical demarcation of the water body and it is encroached at several stretches. Few evictions drives had been undertaken but not completed. The siltation that has occurred has reduced the retention capacity of the lake which acts a reservoir for storm water of the city. This water body/ wetland ecosystem is seasonally flooded with storm water runoff from the surrounding hilly terrain. Silsako Beel provides a natural setting with an emergent urban edge. It has the potential to become an active recreational facility in the city, while leveraging the natural setting to address the storm water management system for the city.



Figure 10-32: Map showing the Silsako polluted wetland Stretch (Source: Action plan for Silsako Beel, PCB, Assam)

10.3.6.2 Inlets and Outlets of Silsako Beel

The Silsako wetland runs in an elongated shape from SW (South-West) to NE (North-East) to direction along a network of streams (inlets and outlet, locally known as nala). The inlets act as feeder channels of Silsako, discharge lots of water and other waste

materials from different sources of the catchment area of the wetland. It feeds by one major and six minor inlet feeder channels, apart from receiving direct atmospheric precipitation.

The major inlet is the Nimaidongjan, which comes from the South Eastern Hills. In the eastern periphery, there are two inlets, viz.

- (i) Noapara inlet – known as Amchang nadi in source region, and Nimaidongjan after entering the wetland.
- (ii) Satgaon inlet – one of the main contributors of water to the wetland.

In the northeastern end, the Bonda inlet joins Silsako from the east. The Nimaidongjan flows to the Brahmaputra River after receiving the Bonda inlet at Narengi Bridge by taking the name as Bondajan. The Hengerabari inlet is the only inlet coming from western side of the wetland. It meets Silsako near the culvert of V.I.P. Road (Six mile-Narengi Road) at Sachal area. In the southern part, the Juripar inlet and the Pakka inlet are flowing to the wetland from the Khanapara Hills. These two inlets carry the agricultural residue and wastewater from Agricultural campus of Khanapara. During the rainy season, these small inlets become like small rivers, which carry excess rainwater and the wetland acts like a natural storage basin.

The Silsako wetland has a distinct drainage system with one major and six minor inlets and feeder channels, which are the '*lifeline*' and only sources of water for the wetland apart from the atmospheric precipitation.

10.3.6.3 Major Locality around the bank

The Beel runs through the heart of the Guwahati city surrounded by villages like Satgaon, Hengrabari, Mathgharia. Revenue dags of three villages namely Hengrabari, Satgaon and No 1 Mathgharia falls under the notified category for Silsako Beel as per the Guwahati Water bodies (Preservation & Conservation) Act 2008.

Guwahati Metropolitan Development Authority (GMDA) under Guwahati Development Department, Govt of Assam has made a comprehensive assessment of land encroached within the Silsako Beel. Government had initiated many eviction drives in the past to remove such encroachments and undertaken huge dredging operations to enhance the storage capacity of the Silsako Beel as this could contribute as storage detention basin to mitigate urban flooding of Guwahati city. Total population residing on either side of the Beel is approximately 3,92,000 and water consumptions stands

at around 52.9 MLD. The details of sewage generation and the gaps in treatment is presented in the given Table 10-25.

Table 10-25: Sewage generation and gaps in treatment at present

Area	Population (Census 2011)	Water Consumption (KLD) @135 lpcd	Sewage Generation (KLD)	No. of STPs proposed	Existing Treatment capacity (KLD)	Gaps in KLD
Silsako Beel	392000	52920	42336	NIL	Nil	42336

(Source: Action plan for Silsako Beel, PCB, Assam, 2019)

10.3.6.4 Drains contributing to pollution

A major City Drain carrying combined sewage has been constructed recently by PWD, Govt of Assam diverting portion of the flow of Bahini river which runs through the city into the Silsako Beel. Moreover, a major drain carrying combined sewage from Meghalaya Catchment is also out falling into the Silsako Beel. Apart from these two, many roadsides carrying combined sewage are out falling into the Beel.

10.3.6.5 Latest water quality and current as per assessment targeted

Pollution Control Board, Govt of Assam makes water quality assessment of all water bodies falls within Guwahati Municipal Area. The water quality test has been carried out at Silsako Beel at one location since July 2017 under NWMP. The summary of water quality parameters for the month of April are as follows.

Table 10-26: Analysis report of Silsako Beel at Chachal- April 2019

SI No.	Parameter	Value
1	D.O. (mg/L)	Nil
2	pH	7.2
3	Cond (µS/cm)	535
4	BOD (mg/L)	46.2
5	COD (mg/L)	170.4
6	NO ₃ - N (mg/L)	0.8
7	TSS (mg/L)	120
8	Turbidity (NTU)	12
9	p-Alkalinity (mg/L)	Nil
10	m-Alkalinity (mg/L)	82
11	Hardness (mg/L)	112
12	Calcium as CaCO ₃ (mg/L)	74
13	Magnesium as CaCO ₃ (mg/L)	38
14	Chloride as Cl (mg/L)	48
15	Total Iron (mg/L)	0.36
16	Copper (mg/L)	0.003
17	Arsenic(mg/L)	BDL
18	Faecal Coliform (MPN/100ml)	2800

(Source: Action plan for Silsako Beel, PCB, Assam, 2019)

10.3.6.6 Characteristics of the river and the major drains

Several Municipal Drains as mentioned above are connected to the Silsako Beel, carrying sewage/ waste/ storm water and discharges directly into the Beel. Major contributor of waste water flow is through the drains coming through Chachal Area & Panjabari Area. Silsako Beel receives waste water through several inlets. The water body has been receiving silt, sewage and solid waste and the water quality has deteriorated beyond limits. Luxuriant growth of water hyacinths, weeds are visible in the water spread area of the Beel. The quality of the water is very poor. Heavy deposit of silt/sludge has been accumulated on the bed of the Beel for years. The details of water quality of the major drains are presented below.

Table 10-27: Analysis report of the major drains contributing to pollution in the Silsako Beel

Sl No.	Parameter	Drain 1 (Chachal Drain)	Drain 1 (Panjabari Drain)
1	D.O. (mg/L)	Nil	Nil
2	pH	7.4	7.3
3	Cond (µS/cm)	584	566
4	BOD (mg/L)	48.0	52.0
5	COD (mg/L)	166.6	174.8
6	NO ₃ - N (mg/L)	2.8	2.6
7	TSS (mg/L)	120	126
8	Turbidity (NTU)	10	12
9	p-Alkalinity (mg/L)	Nil	Nil
10	m-Alkalinity (mg/L)	142.0	164.0
11	Hardness (mg/L)	152.0	150.0
12	Calcium as CaCO ₃ (mg/L)	110.0	102.0
13	Magnesium as CaCO ₃ (mg/L)	42.0	48.0
14	Chloride as Cl (mg/L)	52.0	48.0
15	Total Iron (mg/L)	1.2	1.6
16	Copper (mg/L)	0.004	0.031
17	Arsenic(mg/L)	BDL	BDL
18	Faecal Coliform (MPN/100ml)	2300	3900

(Source: Action plan for Silsako Beel, PCB, Assam, 2019)

10.3.6.7 Ground water quality in the polluted river stretch

The water quality is found to be well within the permissible limit for drinking, irrigation and industrial purposes. Due to slightly higher content of iron in some sporadic patches of the area and fluoride content exceeding permissible limit in some pockets in and around Guwahati City, water needs to be treated before being used for drinking purpose.

Table 10-28: Ground water Quality of Satgaon area (catchment of Silsako Beel) under NWMP May 2019

Sl. No.	Parameter	Value
1	pH	7.7
2	Cond ($\mu\text{S}/\text{cm}$)	317
3	BOD (mg/L)	2.5
5	COD (mg/L)	8.0
6	NO ₃ - N (mg/L)	1.5
7	TSS (mg/L)	28.0
8	Turbidity (NTU)	5
9	p-Alkalinity (mg/L)	Nil
10	m-Alkalinity (mg/L)	120.0
11	Hardness (mg/L)	100.0
12	Calcium as CaCO ₃ (mg/L)	78.0
13	Magnesium as CaCO ₃ (mg/L)	22.0
14	Chloride as Cl (mg/L)	20.0
15	Total Iron (mg/L)	0.62
16	Copper (mg/L)	0.005
17	Arsenic(mg/L)	0.004

(Source: Action plan for Silsako Beel, PCB, Assam, 2019)

10.3.6.8 Flood Plain Zone near Silsako Beel

Hengrabari, Satgaon and No. 1 Mathgharia are highly vulnerable to flash flood during monsoon, these are low lying areas situated near to Silsako Beel.

10.3.6.9 Drainage System/ sewerage network present/ proposed

Presently in Guwahati city, there is no separate sewerage network. All the existing Storm Water drains carries the sewages coming from households and then out falling into the major Rivers, Beels including Silsako Beel and then out falling into the Brahmaputra River. Under JICA, funding, A comprehensive citywide sewerage network plan with STPs in Guwahati city is envisaged and is in feasibility stage. However, Govt of Assam under GMDA has proposed the following measures for improving the water quality of Silsako Beel.

10.3.6.10 Causes of Decline and Degradation of Wetland

- The valuable wetland is gradually dying mainly due to human factors such as Encroachment, higher level of pollution, siltation, and choking up of the streams and nallas.
- The primary causes behind these factors are the horizontal expansion of the urban settlement as a result as a result of increasing population of the City (both due to natural growth and in-migration), agricultural expansion, pollution from the industrial units and laying of the tracks for the railways and roadways.

- The streams and nallas contributing water to the Silsako wetland have been blocked due to disposal of domestic, industrial and agricultural wastes in these small watercourses.
- Heavy siltation has taken place due to quarrying of rocks and weathered material from the nearby hills, from where lot of sediment is transported to the wetlands during the rains.
- Moreover, the dumping of soil in the wetland for different construction works has also caused heavy filling.

10.3.6.11 *Constraints about the Wetland*

Urban Encroachment:

- Encroachers on Silsako wetland have started earth filling thereby blocking the drainage channel. The surrounding buildings encroaching the wetland was more than 5 storey RCC structures. As a result, more of wetland areas have been converted to built-up areas constraints.
- Spread of invasive plants and spread of invasive species particularly water hyacinth
- Garbage disposal/pollution: The surrounding area consists more of residential plots, so dumping of Household as well as industrial waste both solid and liquid takes place thereby polluting the area.

10.3.6.12 *Present activities around the Wetland*

1. Fishing

2. Dredging of land by Guwahati Metropolitan development authority to increase the retention capacity of the Beel. After years of encroachment, the District administration has started eviction drive at the Silsako beel, the water retention capacity has also been reduced by heavy sedimentation and encroachment.

10.3.7 Bondajan Wetland



Figure 10-33: Satellite Image of Bondajan Wetland

Bondajan Beel is in the South-eastern part of the city. On 10th May 2010 Assam Govt. has notified Bondajan wetland in Guwahati Waterbodies (Preservation and Conservation) Act, 2008 to provide for preservation, protection, conservation, regulation, and maintenance of more water bodies within the jurisdiction of Guwahati Metropolitan Development Authority. Bondajan waterbody has four lane PWD road on North, Birkuchi village and Oil India in South, Maria Public School and Matghariya village on West.

Guwahati's wetlands have been degrading. Reasons are natural siltation, earth filling, encroachment, and garbage dumping. In fact, a large part of Guwahati has developed on wetlands leading to their destruction. After the economic boom in the 1990s, wetlands were sold dirt-cheap. Along the Guwahati to Dispur National Highway, the wetlands have been developed with commercial complexes and apartments. Residential areas like Tarun nagar and Lachit nagar (Bera 2011b)⁹. Areas like Six Mile and Jalukbari had wetlands. Marshy areas have also been settled by the urban poor and gradually filled up as the value of the land has increases, they get transferred to economically well-off people. Large settlements of the poor have emerged by filling up low-lying areas at Bhaskar nagar near R.G. Baruah Road, and on marshy land near

⁹ Bera, S. (2011b) "Who messed it up?" Down to Earth, September 15, 2011. <http://www.downtoearth.org.in/content/who-messed-it> (accessed on 16.12.2013)

Pandu area (Borah & Gogoi 2012)¹⁰. In recent years, the government has also allotted large parcels of land in the wetlands of North Guwahati to public and private institutions. The degrading condition of some of the wetlands is discussed below.

All around the city, in the rural settlements as well, which may integrate with GMC area in the future, beels are being encroached upon, with houses on stilts to begin with. In Guwahati, the Hansora and Damol wetlands already have disappeared completely. With the disappearance or eutrophication of the wetlands, which serve as storm water basins, the incidence of flash floods has increased in Guwahati. This led to the Guwahati Water Bodies (Preservation and Conservation) Act, 2008, which notified the Sorousola, Borsola, Silsako, Deepor and Bondajan waterbodies for protection and conservation. However, it has failed to bring any positive changes. The Kamrup Metro district administration constituted four task forces in January 2013 for the preservation, protection, regulation and maintenance of the two important natural waterbodies of the city, Silsako Beel and Bondajan (Kalita 2013)¹¹. Prior to this The Assam Hill Land and Ecological Sites (Prevention and Management) Act, 2006, had been enacted to provide for preservation, protection, regulation, acquisition, and maintenance of hill land and other ecological sites of the State and more specifically within the jurisdiction of the GMC. The implementing authority is the State Government through formation of Advisory Committees, chaired by the Commissioner of Lower Assam Division for Guwahati and the respective commissioner of the other divisions in the rest of the State. This legislation is to prohibit anyone indulging in (i) any earth cutting activities or carrying any portion of a hill land causing damage or destruction of such hill, (ii) removal or filling up or dredging or any way altering any of the ecological sites, and (iii) undertaking any such activity which may cause damage or destruction to the vegetative cover and wildlife resources of any designated area (Das 2012)¹².

¹⁰ Borah, J. and B. Gogoi (2012) "Growth of Slum Areas and Changing Land Use Pattern in Guwahati City, India," *The Clarion* 1:2, pp. 189-195.

¹¹ Kalita, K (2013). "Task Force Constituted to Preserve Wetlands," *The Times of India*, January 18, 2013. <http://timesofindia.indiatimes.com/city/guwahati/Task-forces-constituted-to-preserve-wetlands/articleshow/18071849.cms>

¹² Das, B.N. (2012, 2009) *The Land Laws of Assam*, Guwahati: Assam Law House.

10.4 Floods and River Basins

Floods are an annual recurrent event in Assam, causing damage worth crores and affecting thousands of lives. All rivers in Assam are liable to floods, mainly because they receive heavy rainfall within a short period of time.

Guwahati City is a regional hub and gateway to north-east India. It has a bitter effect on urban growth such as defective roads, drainage system and shortage of open space, etc. The main city where the flooding is predominant is located on the southern bank of the Brahmaputra River which has its extension on the northern bank also. The southern and eastern side is completely, and the northern side partially surrounded by hill locks. The central part of the city has small hillocks. The city is also covered by swamps and water bodies.

The main city where the flooding is predominant is located on the southern bank of the Brahmaputra River which has its extension on the northern bank also

The river waters collect a tremendous amount of silt and other debris, raising the level of riverbeds. Therefore, it becomes impossible for the main channel to cope with the vast volume of water received during the rains. The major river of Assam is the Brahmaputra and is one of the largest rivers in the world. It flows through Assam and Bangladesh before it joins the Bay of Bengal.

The problem of the city Guwahati during the rainy season is very severe, when a major area of the city is under water after a heavy rain of an hour or two. The problem is aggravated with inflows of surface runoffs from the surrounding hills and swelling Brahmaputra River.

Out of various causes the following are considered as prime causes of flood in this city:

- Insufficient natural drainage,
- Silting of the drains,
- Inadequate capacity of the artificial drainage,
- Unauthorized construction in the wetland areas,
- Decrease of surface area available for infiltration into the soil due to construction of building, impervious parking areas, etc. thereby redirecting the rainwater into the drains is another cause of flooding in the city.

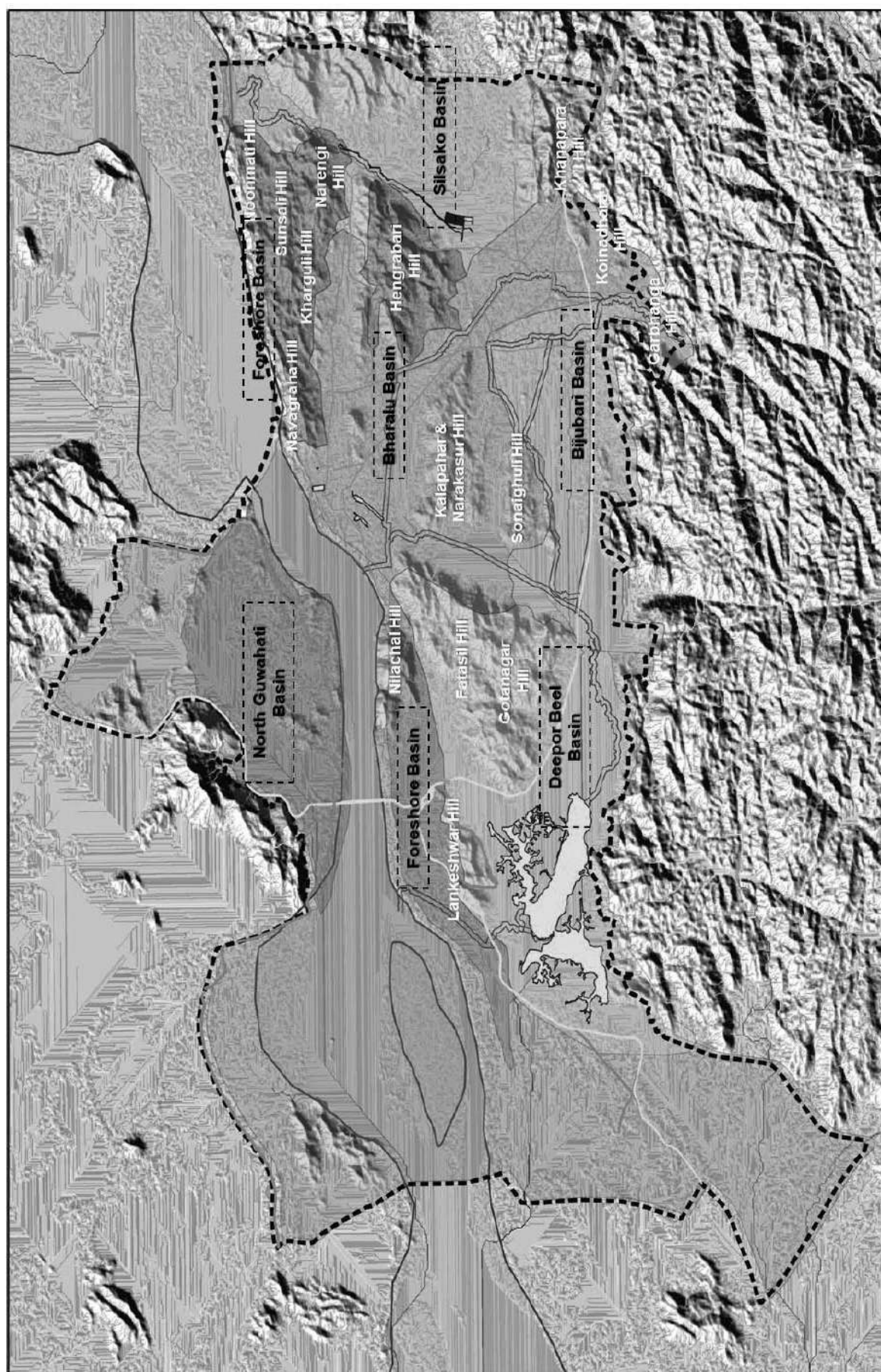


Figure 10-34: Map Showing Drainage Basins and Hills and Hillocks in GMPA

Greater Guwahati has six drainage basins with only two main drainage channels, namely Bharalu and Basistha-Bahini Rivers which ultimately drain into the Brahmaputra River directly or indirectly.

- **Bharalu Basin:** Area is 4,200 hectares and carries the flow through Bharalu River into the Brahmaputra River directly. The basin is the most flood prone having several pockets of low-lying areas and back flow nature from Brahmaputra during rainy season. The hills contributing to Bharalu basin during rainy season are: Kalapahar, Fatasil, Hengrabari, Kharguli.
- **Deepor Beel:** This is the largest drainage basin having 20,135 hectares located on the southern part of city. Runoff from this basin is carried through Basistha-Bahini River which discharges into Deepor Beel connected to the Brahmaputra River at the western outskirt of city. Lankeshwar, Rani Hills, Gotanagar Hills contributes rainwater to re fill Deepor Beel.
- **Silsako Basin:** This basin covers an area of 6,534 hectares and located on the southeastern part of Guwahati. The water from the area drains into Silsako Beel first and run into the Brahmaputra through Bondajan channel.
- **Bijubari Basin:** this Basin is located on southern part of Guwahati. Kalapahar, Sonaighuli and Garbhanga hills contributes rainwater to this Basin which further contributes water to the nearby Basistha and Basistha- Bahini. During monsoon the water flow towards the basin increases which leads to water clogging in this area.
- **Foreshore Basin:** This is a very small area that include some residential, commercial and institutional area. Water accumulates due to rain drains out to the Brahmaputra River through number of small drains as the area is at a high altitude.
- **North Guwahati Basin:** This basin covers an area of 3,230 hectares and is located on the northern bank of the Brahmaputra River. As the area is at a higher level, water from the basin drains into the Brahmaputra River directly through small streams like Ghorajan

The current natural drainage of Guwahati metropolitan area on the south bank of the Brahmaputra is mainly through the Bharalu River and Basistha Bahini River flowing into the Deepor Beel. The Deepor Beel also receives discharge from a large part of the city and adjoining hills on southern side and ultimately disposes the discharges into the Brahmaputra through Khanajan River.

10.5 Hills and Reserve Forests

The southern and eastern sides of the city are surrounded by hills. The central part of the city also has small hillocks namely Sarania Hill (193 mt), Nabagraha Hill (217 mt), Nilachal Hill (193 mt) and Chunsali Hill (293 mt).

Assam's total recorded forest area (RFA) is 26,832 sq.km, including 17,864 sq.km of Reserved Forest and 8,968 square kilometres of Unclassified Forest (India, 2019). In terms of forest canopy density classes, the State has 1,444 sq.km very dense forest, 11,404 sq.km moderately dense forest and 14,825 sq.km open forest.

The forests in Guwahati can be classified into four categories: Reserve Dense Forest, Open Mixed Forest, Scattered Forest, and Degraded Forest with little or no vegetation. Reserve dense forests in Guwahati are notified forest and are declared as protected areas. Within the Guwahati Municipality Area, there are seven reserve forests totalling 2,641 hectares. A large portion of the forest has been encroached upon.

Table 10-29: List of hills and hillocks and the reserve forest areas in Guwahati

SI No.	Hill Name	Hills Coverage Area (Ha.)	Reserve Forest Area Coverage (Ha.)	Percentage of Reserve Forest
1	Jalukbari / Lankeswar	107.18	97.70	91%
2	Fatasil	1327.58	841.00	63%
3	Gotanagar			
4	Kamakhya/ Nilachal	241.72	----	0%
5	Kalapahar	394.71	70.00	18%
6	Narakashur			
7	Kainadhara Hills	20.10	----	0%
8	Khanapara Rf	518.78	----	0%
9	Garbhanga	102.99*	102.99*	100%
10	Kharguli	1327.58	----	0%
11	Nabhagraha			
12	Noon Mati			
13	Sunsali			
14	Narangi			
15	Hangrabari	821.54	628.00	76%
16	Sarania	18.87	7.99	42%

Note: * Falling within GMPA

(Source: AC Nelison, 2011)

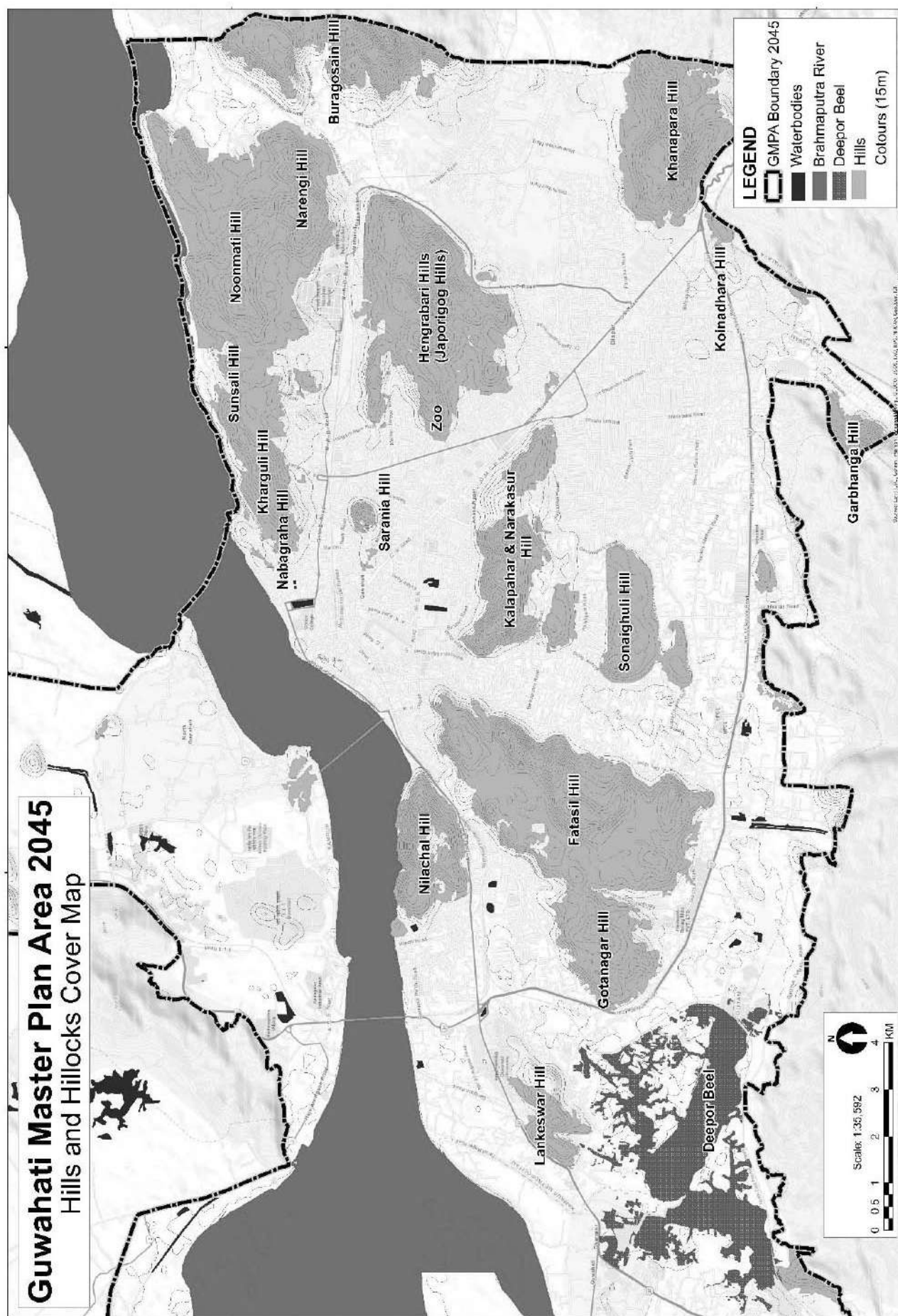


Figure 10-35: Hills and Hillocks Situated in Guwahati

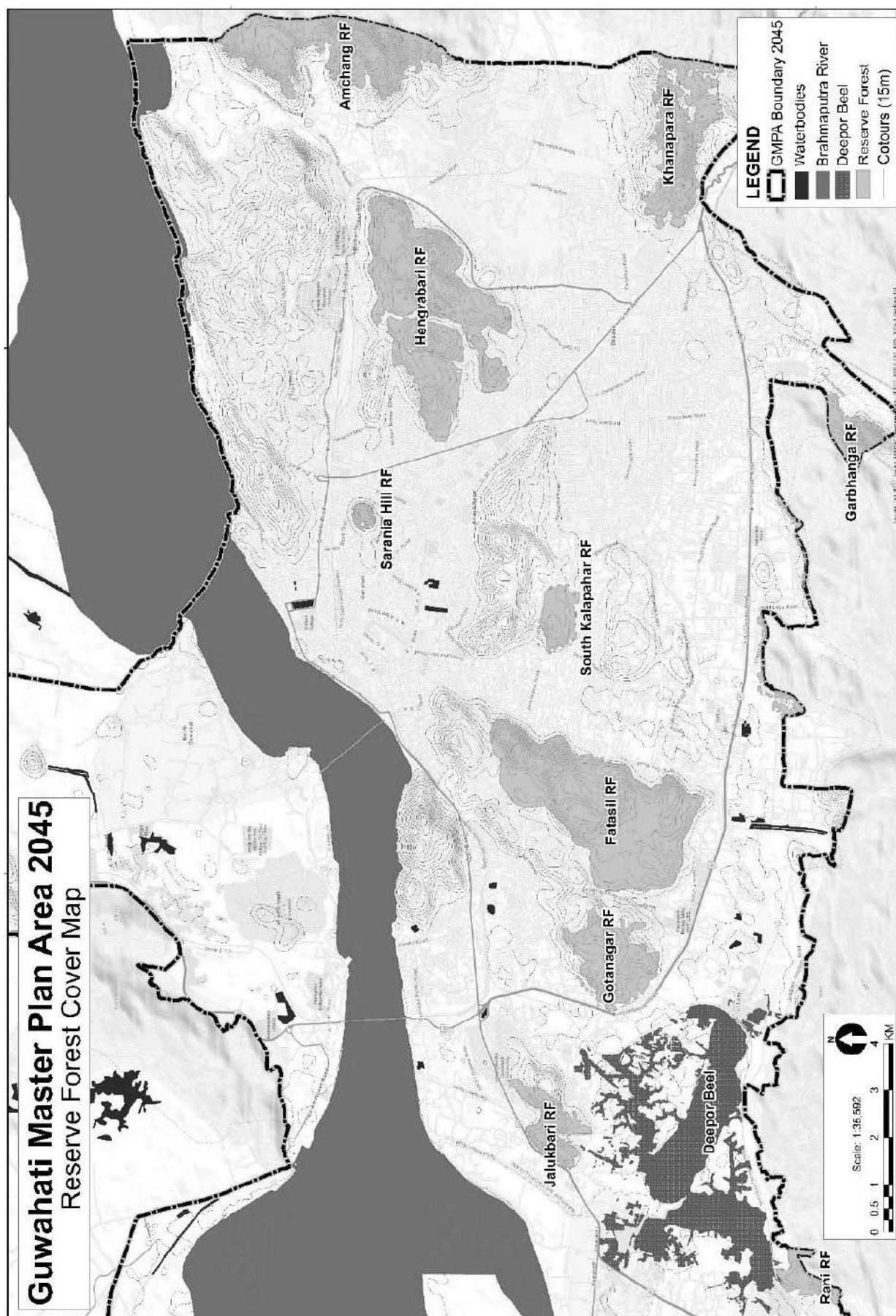
Table 10-30: Details of Reserve Forests in Guwahati and the area encroached within Reserve Forest

Sl. No.	Name of RF	Total Area (ha.)	Area Encroached (ha.)	Notification No. with Date
1	Hengerabari RF including Assam State Zoo - cum - Botanical Garden	628	385	NIL Dt: 13/1/1972
2	Gotanasar RF	171	90	FRS. 79/84/2 Dt: 16/3/1984
3	Jalukbari RF	97.7	NIL	FRS.349/89/12 Dt: 03/5/1990
4	Fatasil RF	670	220	FOR/Sett/550/61/24 Dt: 31/12/1966
5	Sarania Hill RF	7.99	0.5	FRS/15/50/27 Dt:25/3/1989
6	South Kalapahar RF	70	70	FRS.2/82/27 Dt: 25/9/1989
7	Garbhanga RF including I st Edition	18860.58 102.99*	2210 102.99*	19922 - R Dt: 15/7/1926 and FRS. 197/87/42 Dt:19/9/1990
8	Rani RF**	4370	3	13 Dt: 25/7/1882

Note: *Area falling within GMPA , ** Falling Outside GMPA

(Source: Office of The Range Forest Officer, 2019)

The city of Guwahati is the biggest metropolis in Northeast India and also happens to be a part of Indo-Burma Biodiversity Hotspot. It is the capital city of the state of Assam with a total area of 328 sq. km. having a population of around a million with a population density of 3481 person per sq. km as per 2011 census data. The city is situated on an undulating plain with varying altitudes of 49.5–55.5 m above mean sea level. And Wildlife Sanctuaries (Deepor beel WLS and Amchang WLS) along with an internationally acclaimed wetland and Ramsar site, the Deepor beel, within the city limits. The mighty river the Brahmaputra flows through the city. Guwahati has a tropical monsoon climate and receives about 1751.8 mm annual rainfall with an average annual temperature of 23°C. The overall habitat type in the study area mainly comprises of forest patches, scrublands, grasslands, plantations, wetlands, agricultural lands, human settlements and commercial areas. The forest patches are of a moist deciduous type. All these, make the city, a thriving centre for biodiversity. Recent assessments have revealed Guwahati to be the home of around 60 species of fishes, 25 species of amphibians, 53 species of reptiles, 212 species of birds and 36 species of mammals. Out of all these species, 33 species were found to be threatened with extinction and another 62 species needs evaluation. This points out to the fact that our Guwahati has a lot to offer in terms of urban biodiversity. In fact, Guwahati is the only city in India to have its own city's animal: Gangetic Dolphin.



10.5.1 Native Trees Within Green Space of Guwahati:

Forest Department of Guwahati does not marked individual trees of Reserved Forests area. The native species that are found at various reserve forest in Guwahati are: Sal, Dhuna, Titasopa, Udal, Kathal, Aa m, Gamari, Makori Sal, Kanchan, Dudhkoi, Sonaru, Bhatghila, Oxi, Khakan, Paroli. Bhelkor, Kum. Moder, Ghoaneem, Bola, Bansom, Jam, ,Bohera, Hillikha, Azar, Jia, Bagori, Baghnola, Bogipoma, Sam, Dimaru, Gandhsoroi, Hiharu, Hingori' Kadam' 'Morolia, Owtenga, Phu-Igomari, -Seleng, Sida, etc. Apart from these tree species there are so many herb, shrub and climber species are found in the RF area.

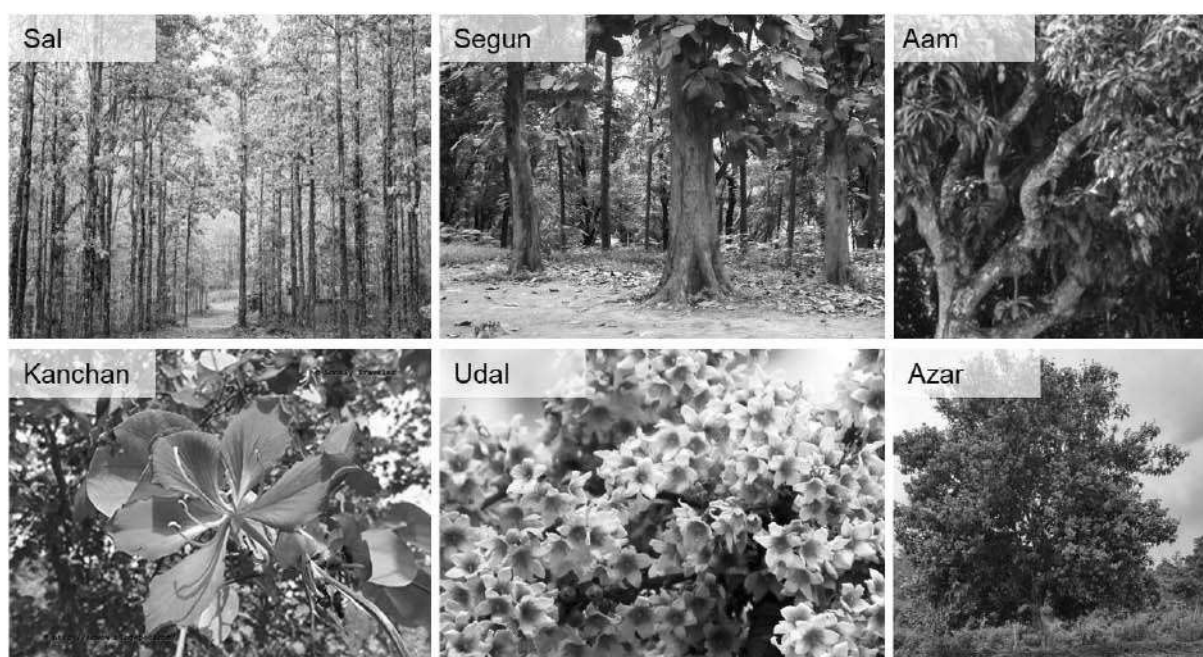


Figure 10-37: Native Trees of Guwahati

10.5.2 Garbhanga Reserve Forest

Garbhanga a small Township, of forest village. The town belong to Garbhanga Reserve Forest. Garbhanga rich in flora and fauna. Its a beautiful land of Tribal villages apart 2 - 3 kilometer each other village total of about 18 village. It is a reserve forest situated in Assam-Meghalaya hilly train border near Guwahati at an 16km distance from the road head one of the famous heritage tourist spot "Basista Temple". In another side it is one and only trekking spot in an around Guwahati. Its a 32km (10 hours) round trek which is toughest for the freshers treker in wilderness. There is a small water fall but full of natural beauty on the way to Garbhanga is the one of attraction point. Garbhanga is the best place to visit especially people found a many

types of species of butterflies where that place belongs a 7th Rank in the world and lastly Garbhanga is the one of the best and adventurist place to trekk down.so put your trekking gears and pack your Rucksack and just trekk down this forest.

It is Worth Mentioning that Garbhanga reserve forest is primarily a high density elephant habitat (Asiatic elephant) and home to an endemic primate species, *Hylobates hoolock* Harlan 1834 (Hooock or White browed Gibbon). The reserve forest is also well known for many rare species of butterflies.



Figure 10-38: Hoolock or White eye browed Gibbon found in Garbhanga RF

10.5.3 Hengrabari Reserve Forest:

Hengrabari is a 620 hectares reserve forest, which is referred to as the Guwahati city's lungs. The Hengrabari reserve forest is also home to Assam state zoo. The Indian Forests Act 1927 defines the procedure to be followed for declaring an area to be a reserved forest, a protected forest, or a village forest. At present, reserved forests and protected forests differ in one important way: Rights to all activities like hunting, grazing, etc. in reserved forests are banned unless specific orders are issued otherwise. In protected areas, rights to activities like hunting and grazing are sometimes given to communities living on the fringes of the forest, who sustain their livelihood partially or wholly from forest resources or products.

10.5.4 Guwahati city decline in forest ecosystem (1911-2015)

Prior to independence the Forest Department, Government of Assam did not reserve any of the hill areas within the city limits. The first Reserved Forest to be constituted was Khanapara RF in the year 1953, with a notified area of 994 Ha, followed by Fatasil RF in 1996 with an area of 669.02 ha. and Hengrabari RF in 1972 with an area of 579 ha, totaling to an area of 2242.02 ha. the Amchang RF (part of which falls within the GMDA area) was also notified in 1972 with an area of 5318 ha. As per the Assam Forest Regulation 1891, all forest areas that are not reserved are to be considered as Unclassed State Forests (USF) where in almost every activity is permitted unless specifically prohibited by an order by the Government which is in contrast to the status of a Reserved Forest where every activity by public is prohibited unless specifically

permitted. Therefore prior to 1953, all the hilly/ forested tracts of the Guwahati city area were falling under the category of USF. The USF areas could be easily diverted for any non-forestry purposes. Human habitation started converting these tracts into permanent habitation since the early part of the century. The trends of occupancy of the hilly forested tracts continued. The growth of settlements in these tracts from 1911 to 2015 is almost exponential. Based on the settlements at different periods in the forested hill tracts within the city limits, the rate of loss of the forest areas was arrived at. The rate of loss between 1911-1967 was 9.82 Ha. Per year (ha./yr), between 1967-86 was 28.37 (ha./yr), between 1986-2010 it was 99.83 (ha./yr), and between 2010-2015 it was 160.34 (ha./yr).

Further, the Forest Department brought a large number of the hilly tracts under the reservation in the 1980-1990 periods. Between 1984 and 1990 six reserved forests were constituted in and around Guwahati city covering a total area of 9291.69 ha among them the RFs falling partly of wholly within the city limits are Gotanagar RF (171 ha), Sarania RF (7.99 ha), South Kalapahar RF (70 ha), South Amchang RF (1550 ha), Jalukbari RF (97.70 ha), and Garbhanga RF first addition (7395 ha). This also resulted in slowing down of settlements within the notified areas. The Forest Department also carried out series of conservation measures including taking up of plantation activities in these areas. The deforestation continues to be a major environmental and ecological issue for Guwahati city. The loss of forest is tabulated in Table 10-31, the Figure 10-39 pictorially depicts the land use change pattern of the hills/forests of the city since 1911.

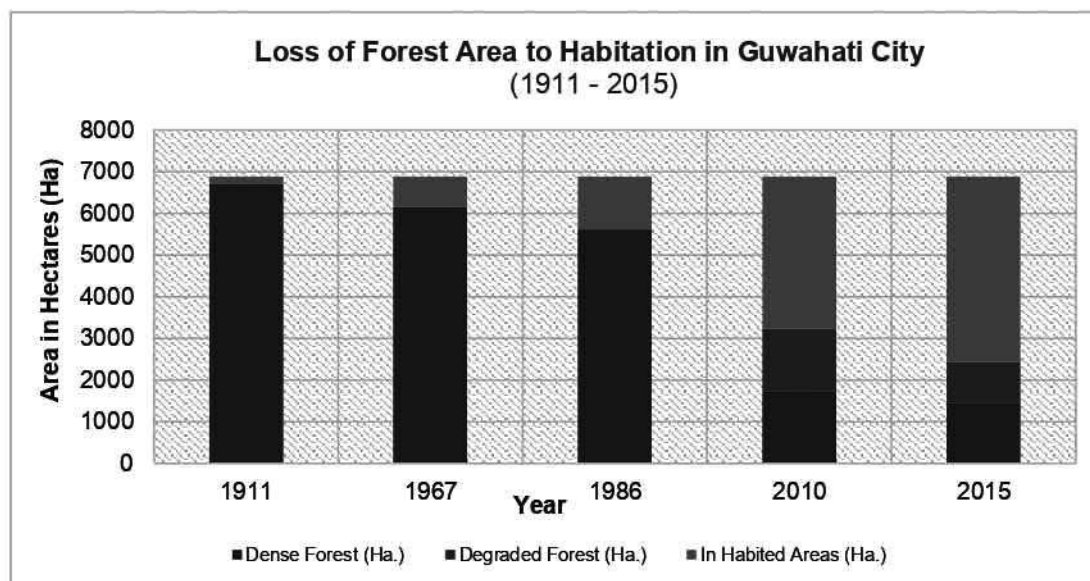


Figure 10-39: Loss of forest areas to habitation in Guwahati

Table 10-31: Loss of Forest in Guwahati City

Year	Dense Forest (Ha.)	Degraded Forest (Ha.)	In Habited Areas (Ha.)	Rate of forest loss (Ha yr ⁻¹)	Cumulative rate of loss of Forest (Ha yr ⁻¹)
1911	6708.63	0	172.63	0	0
1967	6158.44	0	722.82	9.82	9.82
1986	5619.44	0	1261.82	28.37	14.52
2010	1722.84	1500.62	3657.8	99.83	35.2
2015	1438.49	983.27	4459.5	160.34	41.22

(Source: Yadav R, et al., 2016. A Study of Urbanization and Ecosystem Services of Guwahati City from Forest Footprint Perspective. Journal of Ecosystem & Echography)

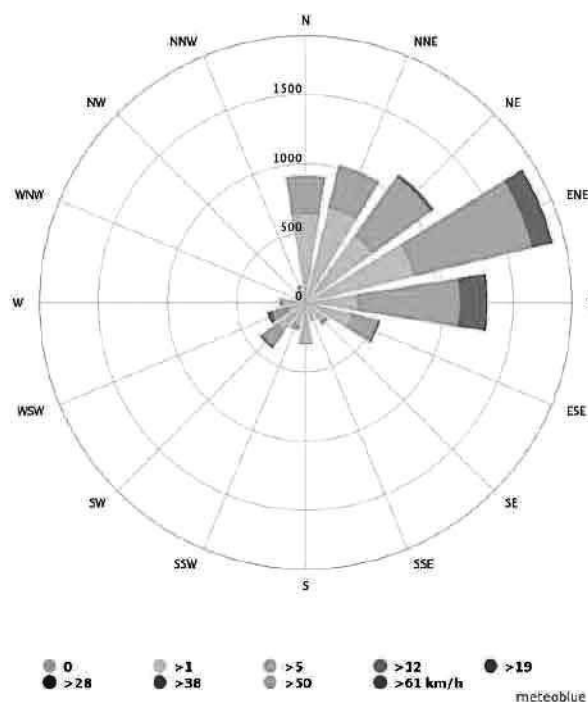
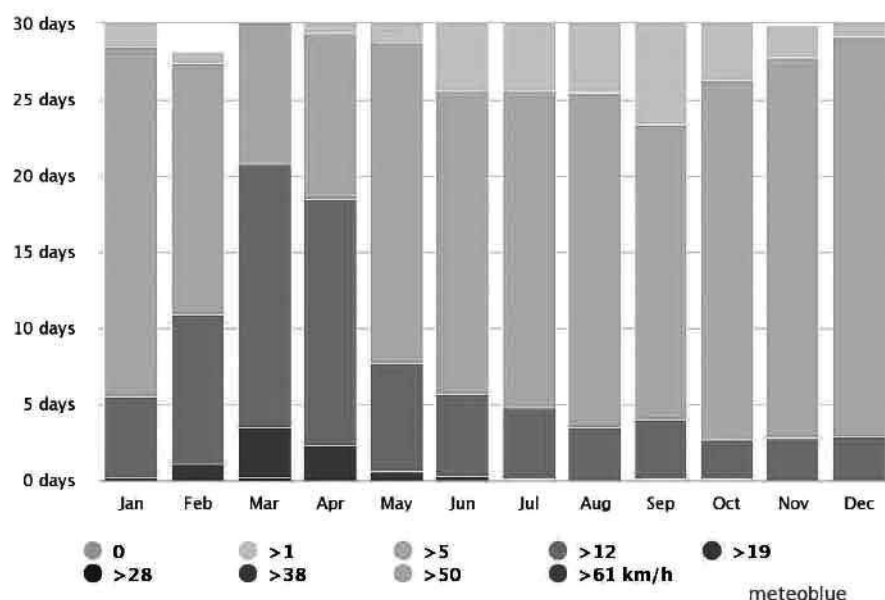
10.6 Wind Direction

This section discusses the wide-area hourly average wind vector (speed and direction) at 10 meters above the ground. The wind experienced at any given location is highly dependent on local topography and other factors, and instantaneous wind speed and direction vary more widely than hourly averages.

The average hourly wind speed in Guwahati experiences mild seasonal variation over the course of the year.

The windier part of the year lasts for 5 months, from February 25 to August 8, with average wind speeds of more than >5 Km per hour. The windiest month of the year in Guwahati is April, with an average hourly wind speed of 7.2 Km per hour.

The calmer time of year lasts for about six-months, from August 8 to February 25. The calmest month of the year in Guwahati is January, with an average hourly wind speed of 5 km per hour.



The Wind Rose diagram of Guwahati shows how many hours per year the wind blows from the indicated direction. The wind is most often from the west for months, Last year (2021) from February 1 to September 22, with a peak percentage of 57% on July

9. The wind is most often from the east for at least 4 months, from September 22 to February 1, with a peak percentage of 53% on January 1.

10.7 Ground Water

The GMPA region is a part of Brahmaputra River basin. The area is drained by Brahmaputra River and its tributaries. Bharalu river, Khanajan are the Important tributaries of Brahmaputra River in Guwahati city. All these tributaries are pereminal and are highly meandering. The lower order streams present a dendritic pattern, but higher older streams show a subparallel pattern. Majority portion of the people of the region are either agriculturists or engaged in related activities. Paddy is the dominant crop of this area and is grown in low land area while high land supports a good number of tea gardens. Other crops of the district are gram, tur, cotton, jute, Mesta, mustard etc.

Ground water occurs in these formations both water table as well as confined conditions and is being developed by dug wells, Piezometers and tube wells. The main aquifers that contribute ground water in Guwahati are Alluvial Aquifer.

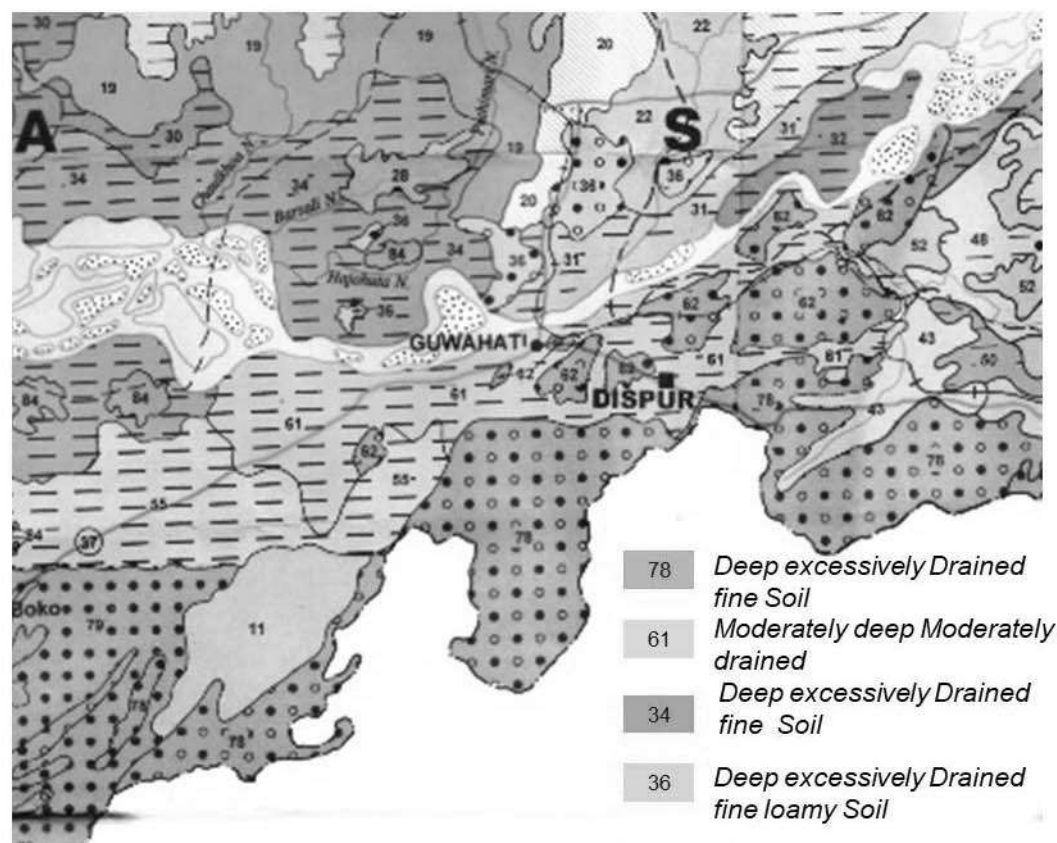


Figure 10-42 Soil Map of Guwahati Region

Description of Soil Categories of GMPA:

- 78: Deep, excessively drained, fine soils occurring on moderately steep side slopes of hills having clayey surface with slight erosion associated with moderately deep excessively drained loamy skeletal soils occurring on moderately steep side slopes of hills with severe erosion and moderate stoniness.
- 61: Moderately deep, moderately well drained coarse loamy soils occurring on level to nearly level active floodplain and on stable river islands having sandy surface with ground water table below one meter of the surface and very severe flooding associated with deep imperfectly drained coarse silty soils occurring on nearly level active flood plain with moderate erosion and very severe flooding.
- 36: Deep, excessively drained, fine loamy soils occurring on moderately to steeply sloping of side slopes of residential hills having loamy surface with severe erosion and slight stoniness associated with shallow, well drained, coarse loamy soils occurring on gently to moderately sloping side slopes of residential hills with moderate erosion and moderate stoniness.
- 34: Very deep, well drained, coarse loamy soils occurring on very gently sloping flood plain having loamy surface with moderate erosion and moderate flooding associated with very deep moderately well drained fine loamy soils occurring on level to nearly level flood plain with slight erosion and moderate flooding.

10.7.1 Hydrogeology

The area consists of two broad hydrogeological units – 1) Pre-Cambrian consolidated rocks and 2) Quaternary alluvium consisting of unconsolidated sediments (Plate-2). Pre-Cambrian consolidated rocks are confined to hilly areas and inselbergs, where ground water occurs in shallow weathered zone, and this can be developed through open wells. The joints and fractures developed due to tectonic activities form potential water bearing zones and suitable for development through construction of bore wells. In the alluvial plain, groundwater occurs in regionally extensive aquifers down to the depth of 305 m. It has a very good yield prospect. The aquifers are consisting of sands of various grades with gravel and are suitable for construction of both shallow and deep tube wells. Groundwater occurs under unconfined to semiconfined condition occupying an area of about 200 sq. km. in and around Baihata –Dumuni chowki which is under artesian condition. In other parts also, the water level rests at shallow depth and in major part, it rests between 2 – 5 metres below ground level (mbgl) during pre-monsoon period. The study of long-term water level trend shows no significant change in rise/fall in water level in the last 10 years. The shallow tube wells tapping aquifers within 50 m depth are capable of yielding about 10 liters per second (lps) in major places, deep tube wells constructed within 95 m depth tapping about 30 m granular

zones are yielding 10 – 20 (liters per minute) lpm. The transmissivity of the aquifer ranges from 41 to 6162 m²/day and the permeability varies from 10 to 59 m/day. In hard rock, the yield of bore well-constructed in greater Guwahati area ranges from 4 to 300 lpm.

10.7.2 Ground Water Resources:

Dynamic ground water resources of Kamrup district are estimated based on the methodology adopted as per GEC 1997, following water level fluctuation and rainfall infiltration factor methodology. The annual dynamic ground water resources as on 2009 are estimated to be 1847.29 MCM while the net annual ground water draft is 715.97 million cubic meters (MCM). The stage of ground water development is 43%. The projected demand for domestic and industrial uses up to 2025 is estimated to be about 105.16 MCM. The district is still under 'Safe' category and sufficient resources are still available for future development.

10.7.3 Ground water Quality

The water samples collected from the monitoring stations and the exploratory wells drilled in different parts of the district were analysed in the Chemical Laboratory of C.G.W.B., NER, Guwahati. The results of the chemical analysis of ground water samples reveal that ground water is fresh, potable, and suitable for both domestic and irrigation purposes. However, due to slightly higher content of iron in some sporadic patches of the area and fluoride content exceeding permissible limit in some pockets in and around Guwahati City, water needs to be treated before being used for drinking purpose.

Table 10-32: Chemical Composition of Ground Water in GMPA

Zone	Chemical Contents of Ground Water							
	Chloride	pH	Hardness	Calcium	Turbidity	Iron	Alkalinity	Acidity
South Central	12.66	6.42	50.00	12.82	3.90	1.61	102.67	99.33
South-East	57.65	6.45	131.33	27.78	9.60	1.02	36.67	93.33
South-West	360.97	6.35	336.67	109.01	2.67	0.25	212.67	136.00
North Guwahati	363.21	6.53	288.00	68.40	5.33	0.58	162.00	128.00

(Source: Farheena Islam, (2014) "Quality Analysis of Ground Water In Greater Guwahati", Journal of Civil Engineering and Environmental Technology)

- Net Ground Water Availability = 912.64 mcm
- Net Annual Ground Water Draft = 715.97 mcm
- Stage of Ground Water Development = 43%
- Future provision for Domestic & Industrial Use = 105.16 mcm

10.8 Pollution

10.8.1 Water Pollution

Consider the city of Guwahati, no doubt, it too, is well located with the river Brahmaputra in its background. The capital of Assam and the only metropolitan city in the entire North- eastern region is also the entry point for the North-east States. Guwahati city gradually developing into a large, crowded city pointing to the extent to which its population has increased over a period of time. With its mounting pressure on land, there is at present no vacant plot at all, big or small, available for sale anything in and around the city. As a result of which, they are facing some chronic civic problems. One such menacing issue in addition to the drinking water crisis is contamination of water. The work of development of Guwahati has been mainly entrusted upon the Guwahati Metropolitan Corporation (GMC), Guwahati Metropolitan Development Authority (GMDA), Jal Board and Guwahati Development Department (GDD).

The river Bharalu which once enhanced the beauty of the Guwahati city today is highly polluted both organically and inorganically. Bacteriological quality of the Bharalu is very poor and is not at all suitable for any human use. A Host of factors are at play in polluting Bharalu. Disposal of untreated municipal sewage and solid waste, untreated wastewater, disposal from domestic, commercial and other sectors, disposal of industrial effluents and other wastes, disposal from automobile servicing centers, hospitals and nursing homes have contributed in polluting Bharalu.

Estrogenic heavy metal analyses of the water are presented in Table 10-33 and Figure 10-43. The result showed the presence of a number of heavy metals with estrogenic activity. The results are demonstrated that heavy metals exceeded permissible safe levels as established by the Environment Protection Agency. The presence of elevated levels of Pb, Cd and Hg is a serious matter of concern and potential for human exposure to heavy metals from eating fish caught in the water bodies as well as drinking water from this polluted area.

Table 10-33: Estrogenic heavy metal concentration in water (mg/L) in three Major water bodies of Guwahati, Assam

Metals	Bharulu River (mg/l)	Borsola Beel (mg/l)	Deepor Beel (mg/l)	Permissible Limits (mg/l)
Cadmium (Cd)	0.012	0.012	0.02	0.003
Chromium (Cr)	0.836	0.808	0.811	0.05
Nickle (Ni)	0.018	0.024	0.023	0.05
Lead (Pb)	2.036	0.529	2.238	0.01
Mercury (Hg)	0.345	0.012	0.139	0.001

(Source: Data collected from International Journal of Chem Tec Research, April/June 2011, vol-3 no. 2 p-701)

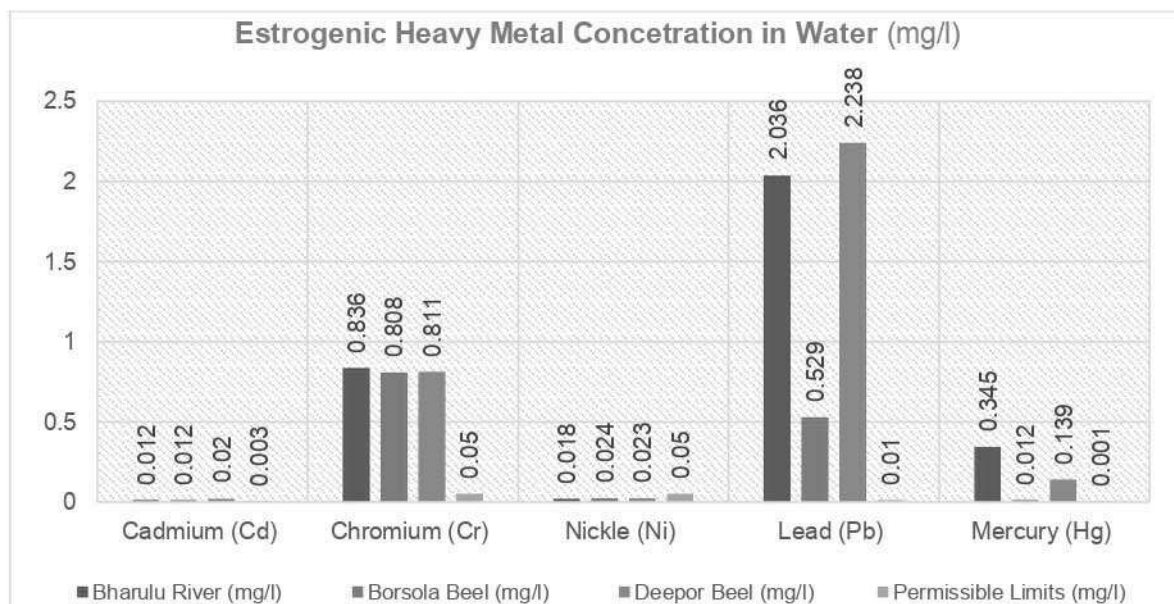


Figure 10-43: Showing Estrogenic heavy metal level in water samples of three Major water bodies of Guwahati, Assam

The degradation of the river started from late 1960s when the Guwahati Refinery started discharging its wastes into the river. Pollution has reached such alarming levels that aquatic life can no longer survive in the Bharalu's highly toxic waters. Large scale encroachments on its banks with tacit support of the authorities has severely hindered the river's water-carrying capacity and its natural courses, shortening its life in the process.

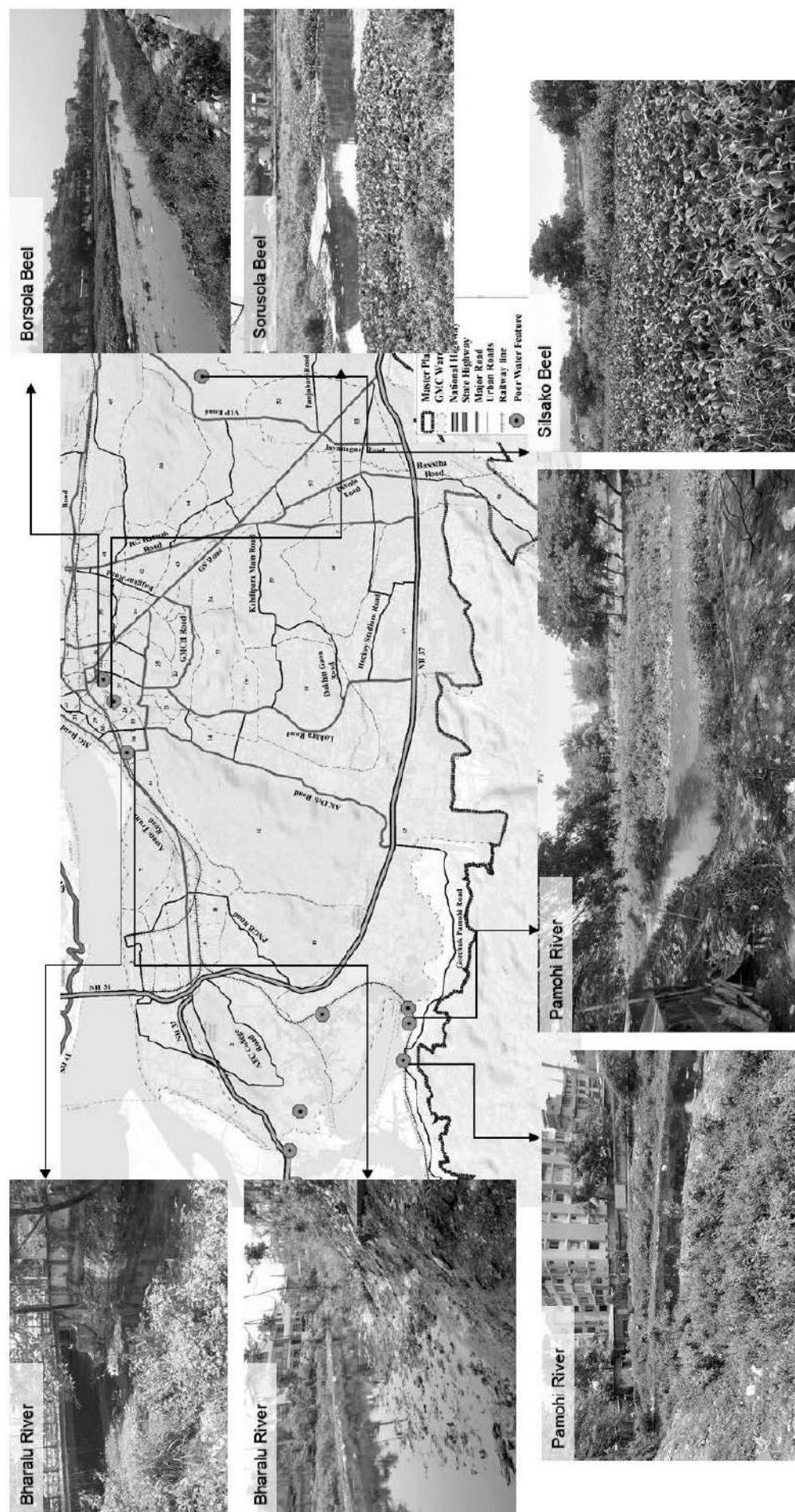


Figure 10-44: Map Showing Poor Water Features at various Water Body Location in GMPA

10.8.2 Soil Pollution

Soil pollution in Guwahati city has become a major concern since the last few decades. The Reason for Soil Pollution in Guwahati is not limited to few sources but it is happening due to many anthropogenic activity. High chemical based Industrial activity, Open solid dumping, traffic and transportation are some major factors being highlighted in this sector.

10.8.2.1 Soil Contamination in Guwahati

Protection of soil is presently a worldwide concern. Urbanization, industrialization and population increase over the last few decades have enhanced the release of toxic organic pollutants, viz. polycyclic aromatic hydrocarbons (PAHs) and heavy metals (HMs) into the environment due to various anthropogenic activities such as fuel burning, industrial emissions, corrosion of metallic particles, etc. Soil systems are the long-term storehouse of such pollutants and are considered to be a steady index of the state of environmental pollution (Momita Das, 2016).¹³

Table 10-34: Description of sampling sites in Guwahati city, Assam, India (Momita Das, 2016)

Site nos	Sampling site	Traffic load	Population load	Land used	Geographical location
S-1	Jalukbari	High	Dense	TA, CA	26°9'26.88"N and 91°40'22.22"E
S-2	Maligaon	Medium	Dense	RA, CA	26°9'32.59"N and 91°41'45.66"E
S-3	Fancy bazaar	Medium	Dense	TA, CA, RA	26°11'3.12"N and 91°44'18.79"E
S-4	Panbazar	Medium	Dense	CA, TA	26°11'17.00"N and 91°44'35.75"E
S-5	Paltanbazar	High	Dense	TA, CA	26°10'43.92"N and 91°45'5.31"E
S-6	Bhangagarh	Medium	Dense	CA, RA	26°10'1.75"N and 91°45'58.63"E
S-7	Dispur	High	Dense	CA, RA, TA	26°8'29.24"N and 91°47'43.50"E
S-8	Ganeshguri	High	Dense	CA, RA, TA	26°8'47.39"N and 91°47'21.27"E
S-9	Khanapara	High	Dense	CA	26°7'13.05"N and 91°49'19.03"E
S-10	Narengi	Low	Sparse	IA, TA, RA	26°10'14.76"N and 91°49'44.63"E
S-11	Noonmati	Low	Sparse	IA, TA, RA	26°11'53.77"N and 91°47'58.73"E
S-12	Chandmari	Medium	Dense	CA, RA	26°11'0.36"N and 91°46'26.68"E
S-13	Basistha chariali	High	Dense	CA, RA, TA	26°6'43.79"N and 91°47'52.58"E
S-14	Lokhra	Medium	Dense	CA, RA	26°6'42.07"N and 91°44'58.12"E
S-15	Basistha (control)	Low	Sparse	RA	26°5'23.57"N and 91°46'38.59"E

TA, Traffic area; CA, Commercial area; RA, Residential area; IA, Industrial area.

Table 10-35: Classification of Soil Contamination by PAHs¹⁰

Class	Concentration of 16 PAHs (µg/g)
Not contaminated	<200
Weakly contaminated	200–600
Contaminated	600–1000
Heavily contaminated	>1000

¹³ Momita Das and D. Patel, 2016, Assessment of Polycyclic Aromatic Hydrocarbons and Heavy Metals Pollution in Soils of Guwahati City, Assam, India, Current Science

Table 10-36: Total concentration of PAHs ($\mu\text{g/g}$) in soil samples of Guwahati city

PAHs	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
Naph	37.4	24.2	41.6	12.1	52.8	29.4	21.8	13.5	80.8	106.2	76.8	20.5	37.5	11.2	7.1
Acy	13.5	18.2	11.1	6.4	15.6	4.7	17.4	3.6	16.8	28.8	21.2	6.0	19.6	4.8	3.1
Acen	21.2	10.7	11.5	2.3	11.2	9.8	ND	ND	14.4	71.0	21.2	10.2	30.6	10.6	ND
Flu	13.8	12.6	12.2	12.2	4.8	1.7	2.0	1.4	7.2	14.4	13.6	31.6	16.9	3.8	0.9
Phen	9.2	9.2	7.7	5.2	9.6	4.8	ND	4.8	6.2	8.2	15.6	4.8	5.8	2.6	ND
Anth	27.4	21.6	20.2	11.8	13.6	9.4	19.6	15.0	19.4	51.6	23.8	17.5	72.4	11.9	10.7
Flan	118.8	55.6	14.6	1.6	3.7	ND	11.8	1.2	12.6	104	130.8	2.7	5.3	4.3	3.2
Pyr	2.2	11.2	1.7	1.1	6.6	2.4	1.5	0.9	3.2	13.6	16.6	ND	1.5	0.8	0.8
BaA	20.0	12.2	19.2	ND	26.7	8.2	13.4	11.6	8.2	28.8	59.6	11.2	16.4	7.8	5.2
Chry	11.2	2.2	5.0	1.3	16.6	2.1	ND	0.2	19.6	67.4	58.8	2.4	15.1	1.7	ND
BbF	9.6	14.3	14.4	11.1	22.1	8.6	4.7	11.0	10.6	25.8	23.6	5.4	10.6	15.5	3.6
BkF	29.8	15.0	14.4	5.4	25.2	7.1	29.2	15.2	16.9	58.8	46.6	11.2	40.8	14.7	0.9
BaP	48.8	20.8	14.6	10.0	15.8	8.1	32.1	73.8	20.6	68.8	47.2	21.6	102.4	10.8	5.3
IP	35.2	10.5	11.3	ND	2.1	0.7	12.2	4.6	0.5	31.7	15.8	17.2	21.0	ND	1.9
DBA	17.6	4.6	9.6	1.6	7.2	0.8	12.0	7.9	15.7	30.6	25.2	0.2	15.8	7.3	ND
BgP	20.7	13.5	22.5	10.8	5.2	9.8	16.1	ND	25.9	32.6	31.6	14.7	23.8	10.1	ND
Σ PAHs	436.4	287.2	231.6	92.9	238.8	107.6	193.8	164.7	278.6	742.3	628	177.2	435.5	117.9	42.7

The 16 PAHs have been analysed to assess anthropogenic pollution levels in the soil of Guwahati city. The concentration of total PAHs was found to be in the range 42.7–742.3 $\mu\text{g/g}$ (Table 10-36). According to the classification of Maliszewska-Kordybach as summarized in Table 10-35, most of the sites are considered to be contaminated. Sampling sites S-10 and S-11, which fall within an oil refinery and a traffic-loaded area, were found to contain substantially higher concentration of total PAHs (742.3 and 628 $\mu\text{g/g}$ respectively) and are considered as highly contaminated, according to the classification in Table 10-35. The other sites that were within the traffic and land-use areas were found to be weakly contaminated and were in the range 436.4–231.6 $\mu\text{g/g}$. S-1 (Jalukbari) which is one of the areas of rapid development with huge traffic, and links the southern and western corridors of the city, and S-13 (Basistha chariali) which links the city with the NH37, contain significantly higher concentration of total PAHs (436.4 and 435.5 $\mu\text{g/g}$ respectively) among all the sites (except the industrial area). The high concentration of PAHs in the industrial area compared to the high traffic areas might be due to release of PAHs during industrial emission along with traffic exhausts. Sites S-4, S-6, S-7, S-8, S-12 and S-14 which showed total concentration of PAHs lower than 200 $\mu\text{g/g}$, were not considered as contaminated²⁰. However, relatively low concentration (42.7 $\mu\text{g/g}$) of PAHs in sample site S-15 (control) implies that the industrial area followed by few of the heavy traffic-loaded areas are the most affected sites, presumably by industrial and vehicular emission ((S-10, S-11) > (S-1, S13) > (S-2, S-3, S-5, S-9)). Among the PAHs, naphthalene, acenaphthylene, anthracene, fluoranthene, chrysene and benzo(a)pyrene were found in higher concentration. These compounds, emitted from incomplete combustion, get adsorbed to particles that

are suspended in the air and are deposited in the soil and dust near the roadside²¹. According to Yang et al. ²², such low molecular weight PAHs are considered to cause significant acute toxicity. Thus, varied environmental conditions at different locations in terms of physico-chemical properties of PAHs could explain the effect on environment and also that industrial effluents are the major source of PAHs contamination followed by vehicular emission in traffic-loaded area (Momita Das, 2016).

10.8.2.2 *Soil Pollution due to polluted water*

Another significant cause of land pollution is when polluted water comes into contact with the soil. This is when pollutants are transmitted from water to soil and cause the soil to degrade in terms of quality. River Bharalu, mora Bharalu, wetlands such as Borsola beel, Sorousola beel located within city which no more possess its original character. From many decades these water bodies transformed into sewer lines or water containing various pollutants. The Bharalu river is the main water body in the city of Guwahati, the gateway to north-east India running through its length, dividing it into two parts. Over the years, the river has become highly polluted due to unstopped disposal of all kinds of waste from the city. Consequently, the land that is coming in contact with the water of the river is getting affected. This project was carried out to study the pollution of the river water and in what way it is causing pollution in the attaching soil. Considering all the facts, the study on the pollution caused by the Bharalu River is undertaken. The river Bharalu is a major recipient of the wastes from the city Guwahati, the capital of Assam. Arising as a small stream from southern flanges of low-lying Khasi Hills, the stream winds through, gaining momentum with width and depth and ultimately falls into the river Brahmaputra. The river Bharalu flows in eastern direction and later flows in a northern way to the river Brahmaputra. The river receives domestic as well as industrial wastes directly through several drains so much so that it looks like a big drain than a river and thus adding massive dosage of pollutants into the river Brahmaputra.

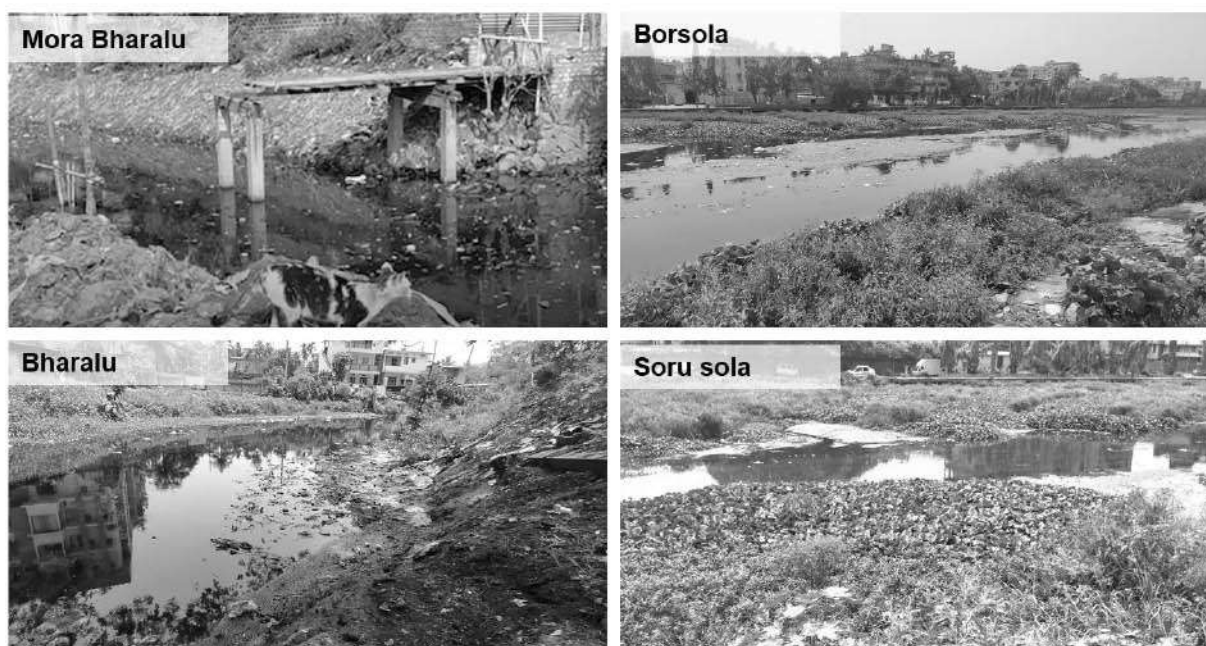


Figure 10-45: Major Polluted Water Bodies in Guwahati

10.8.2.3 Soil Pollution due to Waste Dumping

The growing population in the city increases the production of solid wastes proportionally. These solid wastes are being taken to the dumping ground in the West Belortol landfill site and are then further treated to produce various organic manures. The people on their part lack the basic knowledge about the hazards that can be caused by the improper disposal of such wastes and hence the wastes are seen lying in and across the busy streets, in drains and other such places thereby contributing to the environmental pollution, which in turn accelerates natural resources degradation, causing climate change and impacting the quality of life of the citizens.

Open dumping in Guwahati is an age-old problem, the way municipal waste is disposed of in Guwahati by the citizens poses a greater problem because it leads to land pollution when dumped openly. More importantly, both the waste disposal site of Guwahati that is being managed by GMC is located near major water bodies of the city. Which is naturally fertile land and the disposal mass quantity of waste at this locations not only degrading the soil quality but the leachate coming from these wastes goes directly to the near by water bodies, and polluting them. During heavy monsoon the conditions turned out to be severe. The following figures shows the waste dumping scenario and the map shows the locations of open irregular waste dumping in the city.



Figure 10-47: Open waste Dumping degrading the land quality in Guwahati



Figure 10-48: Landfill site of Guwahati City

10.8.3 Noise Pollution

Noise is one of the most significant sources of environmental pollution in modern cities. It can be defined as an unpleasant and unwanted sound, which now becomes a serious threat to urban life. Noise is like a physical form of pollutants which does not harm directly to the life supporting system namely air, water and soil. But its effects are more directly on the receiver.i.e. human being. The major cause of increasing noise is rapid urbanization, industrialization and population growth.

Guwahati has seen a rapid rise in population in the past few years. People from other parts of the state and the region migrate to the city chiefly for education and occupation.

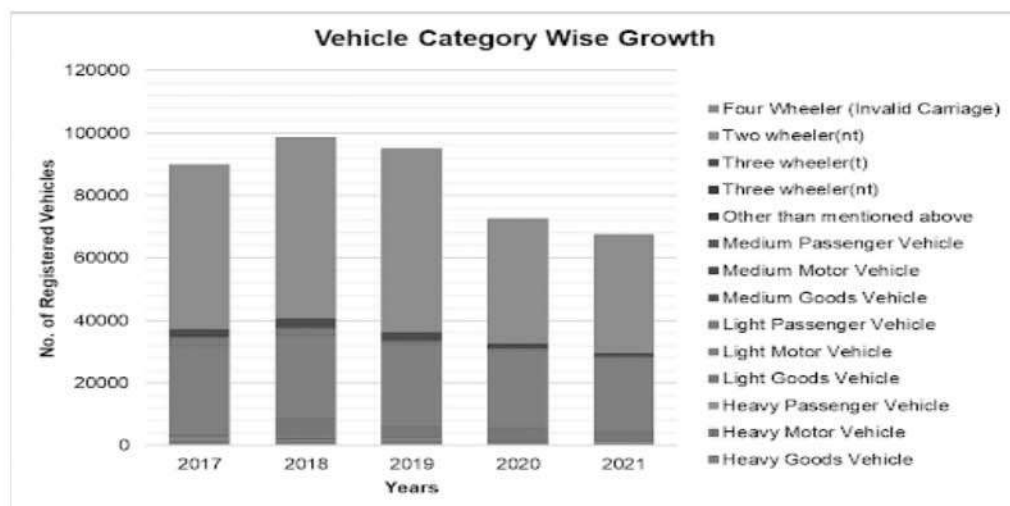


Figure 10-49: Vehicular ownership growth in Guwahati

The above figure indicated the annual vehicular ownership of Guwahati in between 2017 to 2021. Every year significant number of vehicles are being registered in this city. In the year 2018 more than 95,000 new vehicles registered in Guwahati. However during 2020 and 2021 due to covid pandemic situation and due to complete lockdown growth rate of newly registered vehicle slowed down.

Table 10-37: Ambient Air Quality Standards in respect of Noise

Type of Area	Category of Area/ Zones	Limits in dB (A) (A) Leq	
		Day Time*	Night Time**
A	Industrial	75	70
B	Commercial	65	55
C	Residential	55	45
D	Silence***	50	40

Note: *Day time: 6:00am to 10:00pm, ** Night time- 10:00pm to 6:00am ***Silence: Educational and Hospital areas
(Source: The Noise Pollution (Regulation and Control) Rules, 2000)

The noise levels of Guwahati city in most of the places are higher than the standard prescribed by CPCB and BIS "The Noise Pollution (Regulation and Control) Rules, 2000" (Table 10-37). The noise scenario of the city is deteriorating with population growth, exponential increase of vehicles, lack of parking space, poor and narrow condition of roads and in appropriate traffic management.

10.8.3.1 Noise level in Commercial areas

It has been observed that the variations of noise level, Leq in commercial locations of the city is ranged from 66.54 dB (A) to 80.81 dB (A) with standard deviation 3.25 ; 61.18 dB (A) to 77.24 dB (A) with S.D. 3.12 ; and 59.95 dB (A) to 78.24 dB (A) with S.D. 3.92 during 7:00 am to 10:00 am; 12:00 noon to 3:00 pm and 4:00 pm to 8:00 pm respectively. There is almost constant level of noise prolongs for day duration except